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INTERREGIONAL COMPETITION IN THE FROZEN STRAWBERRY INDUSTRY[1,2]

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INTRODUCTION

RAPID GROWTH in the output of frozen fruits and vegetables is a recent and important development in the production and marketing of foods in the United States. This growth has depended on widespread technical advances in the frozen food industry. Freezing techniques have been perfected, efficient preparation, freezing, and transportation facilities have been developed, and cold storage warehouse space for frozen foods has been greatly enlarged in both producing and consuming centers. Finally, there has been rapid expansion in the availability of equipment for the retail display and home storage of frozen foods. The effects of these adjustments in processing and marketing have been supplemented by advances in farm production techniques, such as new varieties, improved disease and pest control, and better production machinery.

Changes in production and distribution methods, along with growth in total population, shifts in its distribution over the United States, and changes in per capita consumption of frozen foods have an important bearing on the comparative advantage of the different producing and processing regions. With continuing growth and investment in this industry, the question of where new facilities can be most effectively located is, therefore, of special interest.

In recognition of this problem, studies of locational advantage in the food freezing industry were initiated several years ago by the California Agricultural Experiment Station and the Agricultural Marketing Service, U. S.

[1] Submitted for publication April 7, 1961.

[2] The results of this study were initially presented in a dissertation, "Interregional Competition in the Frozen Strawberry Industry," submitted by the senior author to the Graduate Division, University of California, in June, 1959. A progress report on this study was also published: C. C. Dennis and L. L. Sammet, *Regional Location of Production and Distribution of Frozen Strawberries,* University of California, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 231 (Berkeley, 1960).

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Department of Agriculture, working coöperatively on a regional research project in the western states. Additional marketing studies were conducted by the Agricultural Marketing Service, and several of these were closely coördinated with the regional study.

While past and continuing work in this area is concerned with the major frozen fruits and vegetables, the present report deals with interregional competition in the growing and processing of frozen strawberries. This is of special significance because the geographic distribution of strawberry production has been shifting rapidly, with consequent effect on the leadership of established areas. The swift expansion of output in California and the other Pacific Coast states has been especially noteworthy. Of particular importance in California has been the development of varietal improvements that have greatly extended the production and harvesting season.

This report presents in simplified terms a theoretical framework for studies of production location, summarizes and adapts the results of previously published studies of farm production and processing costs, and presents additional estimates of interregional transportation costs and of regional levels of strawberry consumption. These data are then used in studies of optimum adjustment in the farm production, processing, and distribution of the actual volume of output of frozen strawberries in a past year—1955—and in regard to projected levels of regional consumption in 1970. (The year 1955 was chosen as the most recent for which detailed information on the consumption of frozen strawberries was available; 1970 was thought to be susceptible to rough projection of certain relationships, yet far enough in the future to be of interest in long-run analysis.) Several analytical models are developed in order to evaluate the effect of alternative levels for some of the more important variables that determine the location of frozen strawberry production.

FRAMEWORK OF ANALYSIS

The study of interregional competition with respect to a given commodity assumes the presence, or the possibility, of locational advantage in at least some aspects of its production and distribution. Such advantages, and different demands among various consuming centers, are the basis for interregional trade flows. The pattern of these flows in an enterprise economy involving numerous producing and consuming centers reflects the interaction of economic forces that determine: (1) product price in particular markets—a function of supplies and demands of the product in the various markets; and (2) farm production and transfer costs in the various regions—in each region a function of its location with respect to markets and the opportunity costs, within the region, for services required in the production and processing of the commodity under consideration.

Theoretical Concepts

Concepts currently applied in studies of location economics owe much to an early publication by Von Thunen (1930 ed.).[5] In this work a highly simplified model, involving a single market centered in an area of uniform production potential, was used to explain the location of different types of commodi-

[5] See "Literature Cited" for citations referred to in the text by author and date.

ties supplied to the single market. More elaborate formulations have appeared in later works, such as those of Fetter (1924), Hoover (1937), Isard (1956), Dunn (1954), and Greenhut (1958). The present study, with modifications, is patterned on these earlier studies. This involves consideration of relationships affecting supply, demand, and the market through which equilibrium of supply and demand and allocation of regional supplies is accomplished.

Supply. The available supply of a given commodity is usually visualized as an increasing function of price—that is, larger quantities are supplied as price rises. The nature of this relationship is affected by the available opportunities for adjustment in supply to price changes, and this often leads to important distinctions, as between short- and long-run supply response.

With agricultural commodities, as well as many others, aggregate supply in the market short run is often fixed in amount regardless of price, and the relation of supply to price is highly inelastic. As opportunities for adjustment increase, supply may become more elastic, depending on perishability of the product, storage facilities, and expectations of suppliers. If suppliers feel, for example, that the price at a future time will be sufficiently above present price to offset storage costs, they will be induced to store some of the present supply, thereby reducing the amounts immediately available, raising present price, and imparting some elasticity to the supply function. There may be, of course, a price below which handling costs of an already produced supply are not covered, resulting in a highly elastic supply response at that price.

Supply adjustment is related to capacity for adjustment in the type and quantities of resources employed in production. If supplies are expanded, this may involve intensification on existing fixed factors of production, the addition of new production areas more distant from the market, and the use of resources less well adapted to production of the given commodity than those originally employed. Increased long-run supply then involves increased marginal cost, at least for some suppliers. For a reduction in long-run supply, the reverse is true. The long-run supply curve is ordinarily visualized as sloping upward with increasing price, and to be much more elastic than the short-run supply curve.

For the individual producer, the optimum long-run adjustment requires a choice among all available alternatives as to products and markets, combinations of products, and production techniques, as well as among other opportunities for use of the entrepreneur's resources. The criterion widely assumed to be applied in deciding among alternatives is maximization of net return. With respect to agricultural production, this frequently is considered to mean maximizing net returns to the fixed resource—land. Decisions in this framework require knowledge by the entrepreneur of the production functions, factor costs, and product prices facing him for each alternative use of his resources. These data are required with respect to both present and future production periods. In this presentation, certain knowledge of future—as well as present—production, product price, and cost relationships is assumed. This greatly simplifies the circumstances commonly encountered in practical situations, where uncertainty as to future relationships may have an important influence on entrepreneurial decisions. The simplified formulation, however, is believed to be adequate for the present purposes.

The decision-making situation for the individual producer is illustrated in simplified form in figure 1, which represents net returns per unit of land from each of two alternative products, 1 and 2, in relation to distance between producing area and market. When produced at the market, net returns from alternative 1 are OA, and they fall, with increased distance from point of production to the market, along the line AC. Similarly, maximum net returns with alternative 2 are OB, and they decline with increased distance from the market along line BD. The slopes of AC and BD represent the reduction in revenue per unit distance (equal to unit transportation costs per unit distance) between producing and market points. At any given distance, net returns per unit of land are assumed to be the same for all producers. To maximize profits, producers nearer than OE to the market would choose alternative 1; at distance OE, either alternative would be equally good; and for distances in the range E to D, alternative 2 would be chosen.

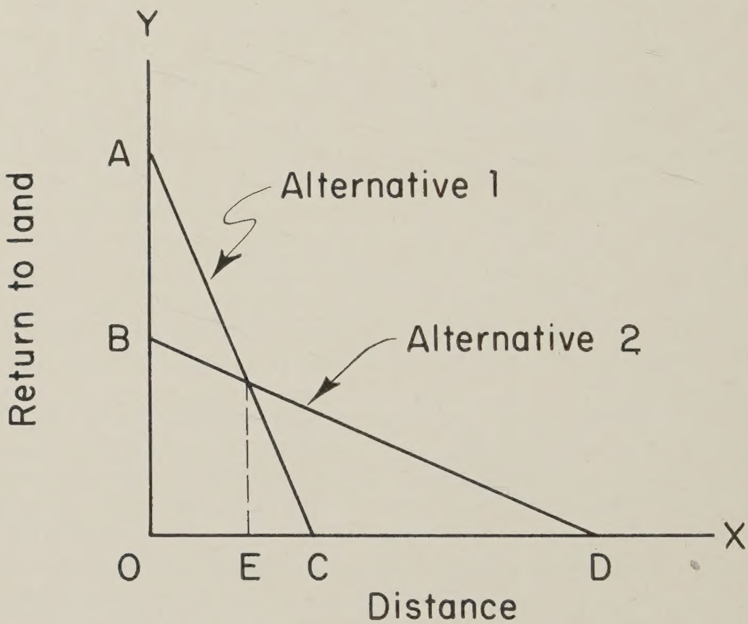

Fig. 1. Rent line formation.

In the long run and with perfect markets, the positive net return to land will be capitalized into land value, and with this added cost, net returns to land become zero. (It is recognized that the perfect adjustment described here is seldom precisely attained in real markets, but the tendency is toward that point.) This result is represented in figure 2. Net returns with alternative 1 are zero in the distance range O′E′ and they are zero with alternative 2 in the range E′D′. In the distance range O′E′—with land costs determined by net returns from alternative 1—net returns from alternative 2, the inferior choice, are negative. Long-run unit costs with alternative 1 are equal for all producers in zone O′E′; and in zone E′D′ long-run unit costs are equal for all producers with respect to alternative 2. Maximum land values

occur at zero distance between production and market points and they decline to zero at distance O′D′.

An important simplification in the above is the representation of transportation cost as a continuous and linear function of distance. In reality, irregularities usually are found in the physical transportation network, and there may be discontinuities in the rate-distance charge for movement over a given transport medium. Adaptation of both theory and problem solution to such circumstances may be required (see Dunn, 1954; pp. 38–39, 56–57).

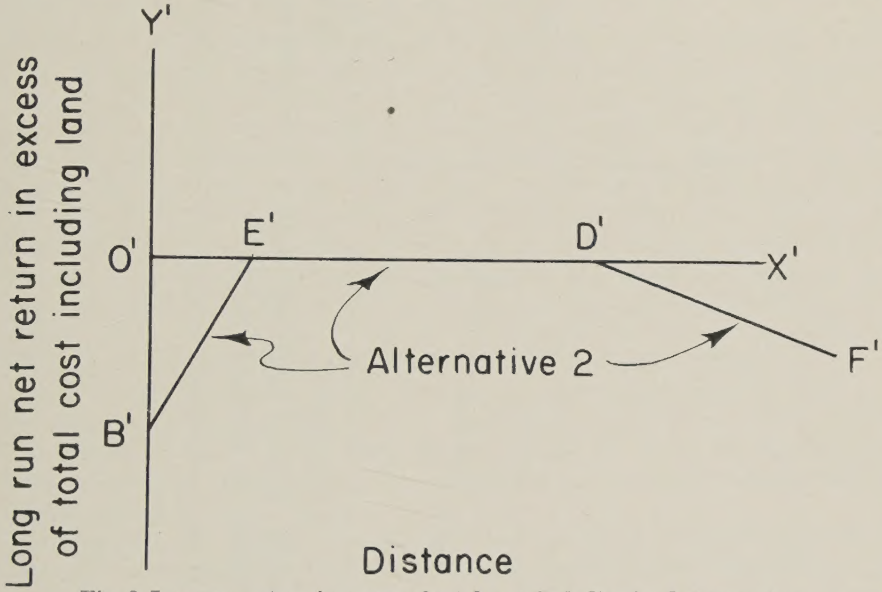

Fig. 2. Long-run return in excess of total cost, including land charge when Alternative 2 is employed.

These relationships can also be represented algebraically. Consider two producers, A and B, located at distances (a) and (b) from the market, who select their best alternatives as described above. If the per unit transfer costs are T_a and T_b and marginal production costs, exclusive of land, are C_a and C_b for producers A and B, respectively, then the return to land from the marginal unit of output is:

$$P_a - (T_a + C_a) \text{ for producer A, and}$$
$$P_b - (T_b + C_b) \text{ for producer B}$$

where

P_a and P_b are equal and represent the market product prices received by A and B.

If these returns are not equal, the high-return land will be bid up in land rent or money value to a level that eliminates the difference. If C_a and C_b are redefined to include land rent to the entrepreneur, then in the long run:

$$P_a - (T_a + C_a) = P_b - (T_b + C_b) = O,$$

and production occurs in all areas at equal total unit costs.

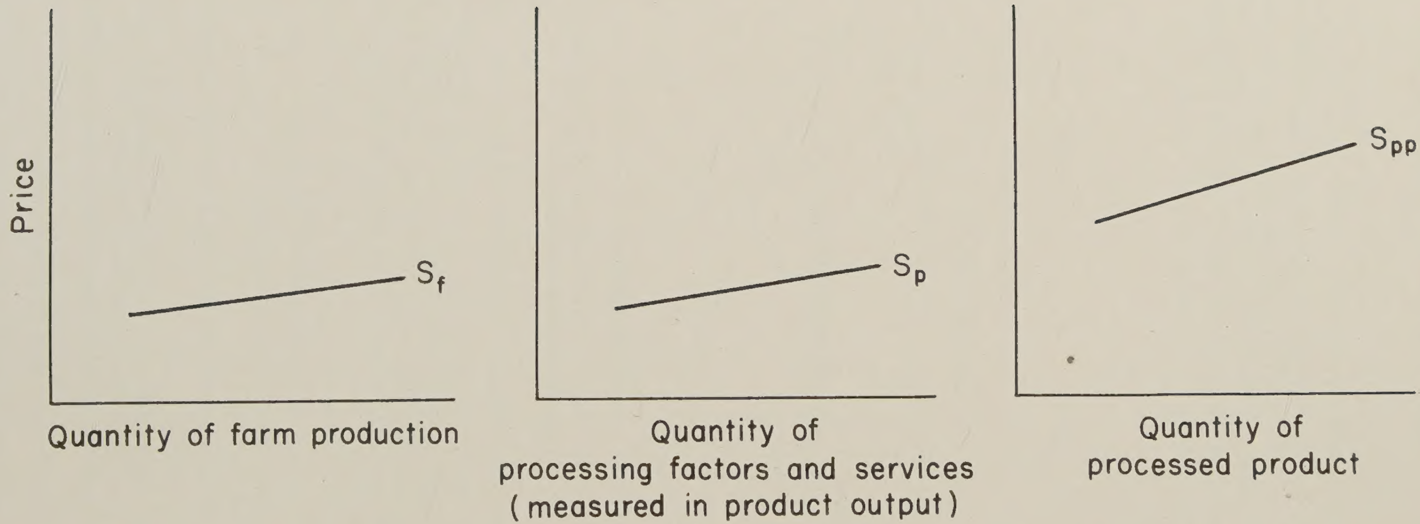

Fig. 3. Addition of farm production and processing supply schedules to form a processed product supply schedule.

A change in the prices of either the products or the factors entering into the production of those products will alter the return to land and influence the production decision. A change in technology in the production of this or other products competing for the same resources may also change the production decision. Assuming production technology, factor prices, and prices of other products competing for the same resources all remain constant while the price of a given product varies, the resulting change in return to land will cause the quantity of land devoted to this product to vary in the same direction as product price. For a given producer or producing area this is reflected in the usual positively sloping supply schedule.

For each region there is a supply function for processing services just as there is a supply function for farm production. The quantity of these services supplied for processing is also expected to vary in the same direction as their prices and so result in an upward sloping supply curve. In the absence of exogenous disturbances, in the long run, the most efficient techniques will be used, plants will be of optimum size, and productive factors will be priced according to their productivity. (Plant size will be jointly determined with regional farm production. For instance, if production demanded from an area is insufficient to require processing plants of most efficient size, smaller, less efficient plants will be used.) Average processing costs within a given region will, therefore, tend toward equality in equilibrium. The level of long-run processing cost may, however, differ among regions.

The processed product supply schedule is constructed from the farm supply and processing supply schedules. In figure 3, the separate panels present hypothetical farm and processing supply schedules as well as the combination, by vertical addition, of those schedules to form a processed product supply schedule (S_{pp}).

Similar supply schedules exist for other resources and services, such as wholesaling and retailing, which are used in the marketing channel from the processor to the consumer. These are similarly added to the processed product supply schedule to obtain the retail supply schedule.

Demand. Explanation of the underlying demand relationships usually begins with the individual household, which is assumed to have a unique pattern of preferences. These preferences operate in a complex social, economic, and psychological setting wherein the individual allocates time between leisure and gainful employment, allocates net earnings between savings and expenditures, and allocates expenditures among a wide range of consumer products. For most individuals and products the quantity taken of a given commodity—all other factors constant—increases as price falls. Similarly, other factors constant, the individual's demand-price response may shift with changes over time in such factors as individual preferences, changes in personal net income, and changes in the prices of substitute or complementary products. The total demand of all consumers is an aggregate reflection of the price-quantity relationships of individual households. Therefore total demand for a particular commodity—all other factors constant—generally may be visualized as inversely related to price. This assumes a product of positive utility—the usual case. It is difficult to think of a product of other than positive utility that would be of interest in a study of interregional trade.

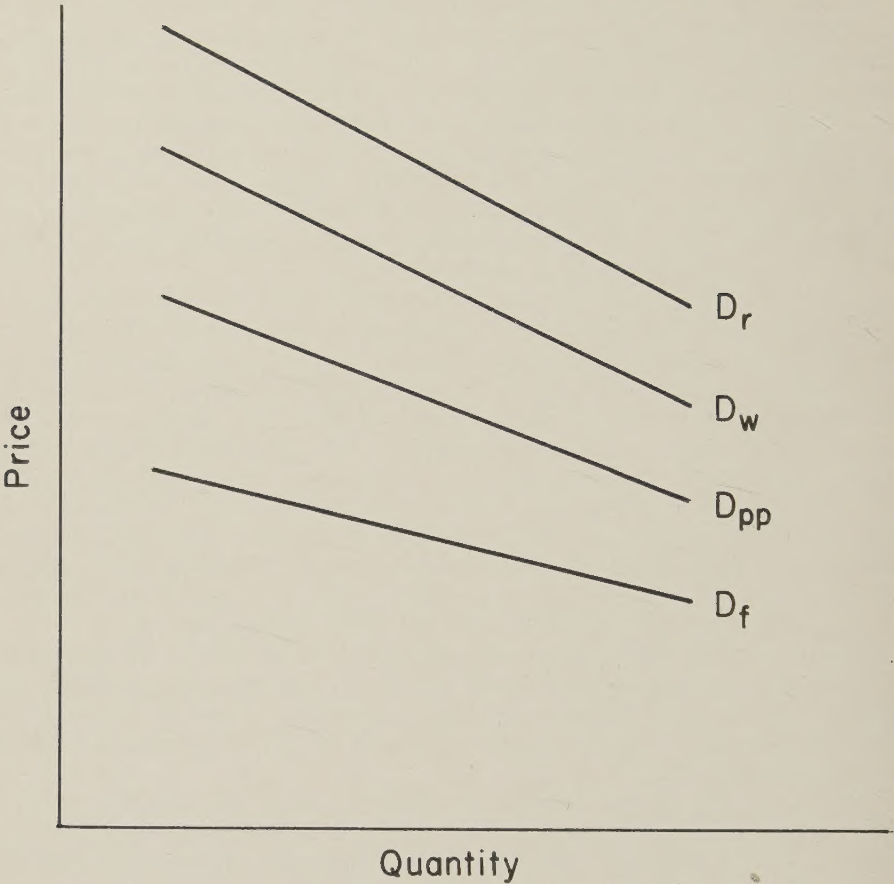

Fig. 4. Relationship of retail demand curve and derived wholesale, processor, and farm-level demand functions.

The retail demand-price relationships for a product, as described above, represent in aggregate the indirect demand of consumers for the factors and services which enter into the manufacture of that product; that is, the raw materials and services involved in processing, transportation, wholesaling, and retailing. This is represented in figure 4, which portrays aggregate demand in relation to product price for the aggregation of factors and services at various levels in the marketing channel required to supply given quantities of a particular good. The individual demand curves are visualized in a manner analogous to the derivation of supply curves. (An alternative view of derived demand at any level in the marketing channel considers it to be the retail demand less appropriate marketing charges.) In supply-curve derivation, supply functions at successive levels in the marketing channel are added together. That is, the supply function for processed product consists of the farm supply plus processing supply functions, and wholesale supply consists of the sum of the processed product and wholesaling services supply functions. In demand derivation, the order is reversed. Demand at the wholesale

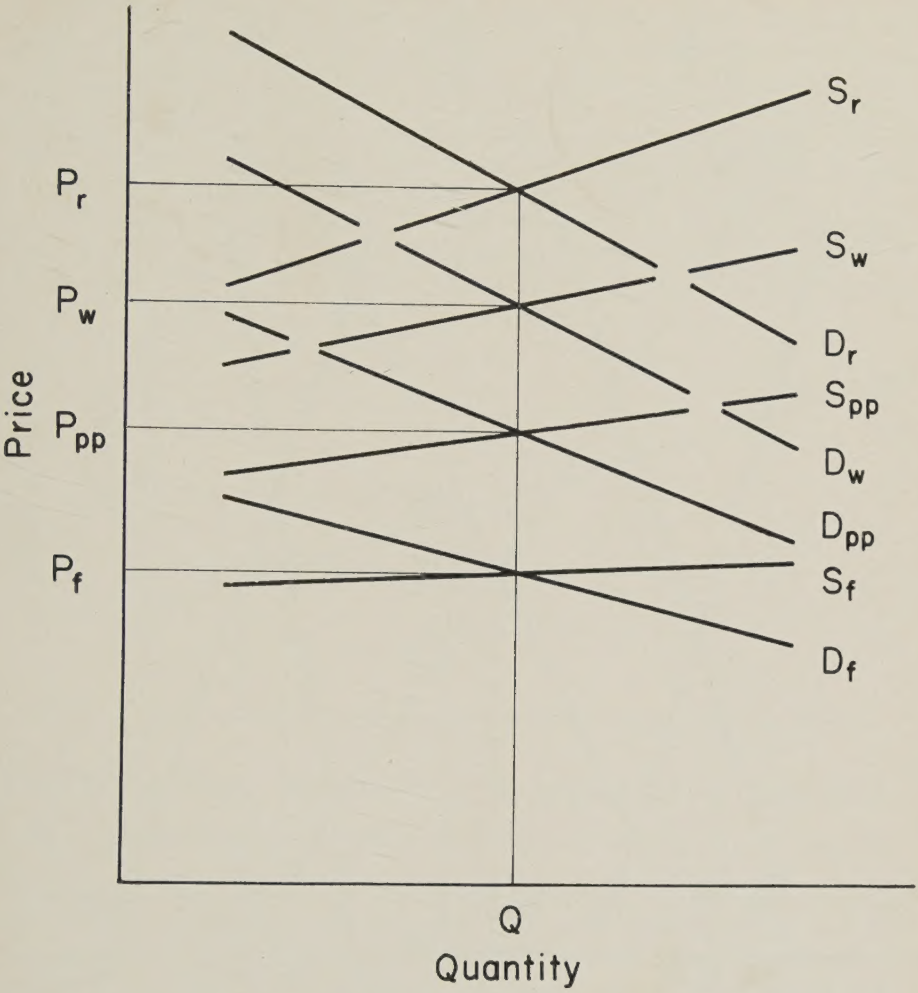

Fig. 5. Interaction of supply and demand functions to determine equilibrium price and quantity at various levels in the marketing channel.

level consists of retail demand less the demand for retail services; processed product demand in turn consists of wholesale demand less the demand for wholesaling services; and farm-level demand is the processed product demand less the demand for processing factors and services. The relationship of demands at various levels in the marketing channel is shown in the hypothetical demand map of figure 4 where D_r, D_w, D_{pp}, and D_f are the demands at the retail, wholesale, processing plant, and farm levels, respectively.

The Market. The market functions to bring into balance these demands and supplies of materials and services at successive levels. This is represented for an isolated market in figure 5, which portrays the interaction of these forces to determine price, quantity supplied, and quantity consumed. In this figure, S_f, S_{pp}, S_w, and S_r represent farm, processor, wholesale, and retail

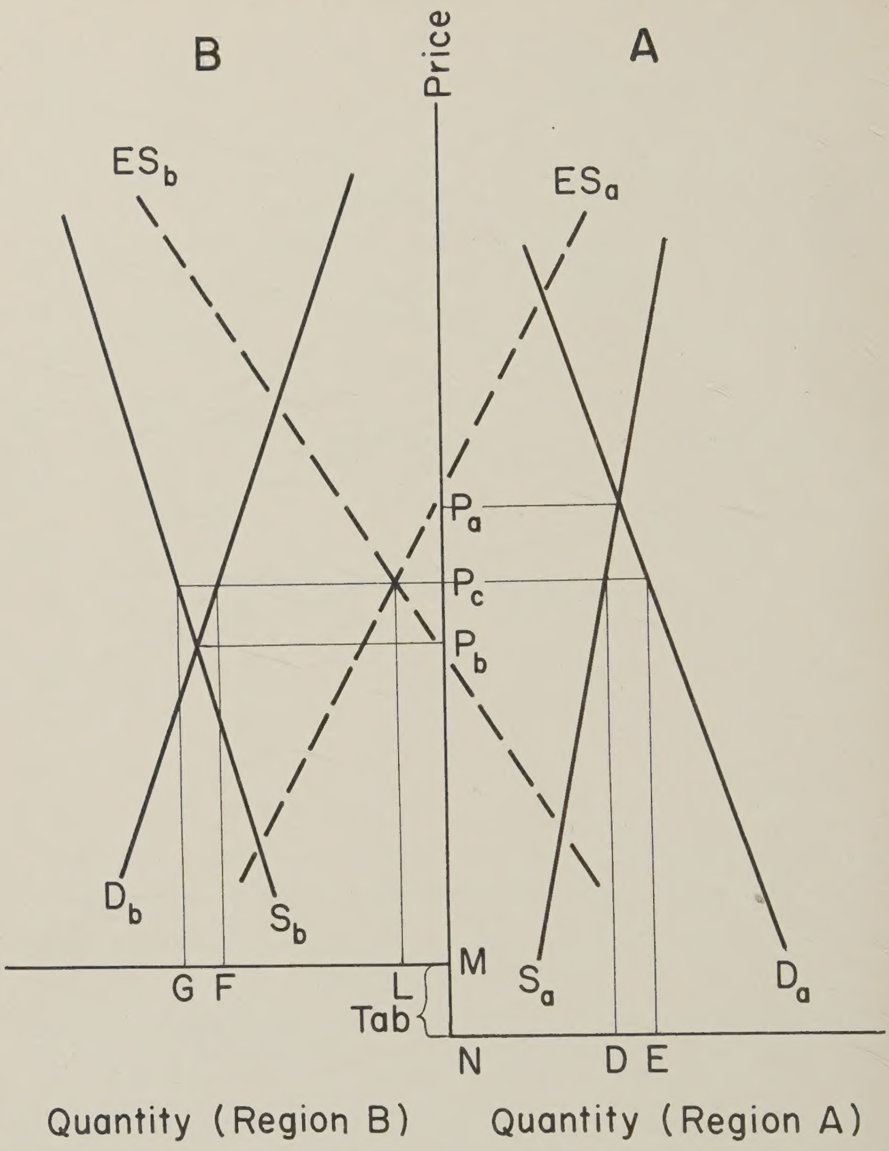

Fig. 6. Determination of equilibrium prices and product flows in the two-region, competitive case, using a back-to-back diagram with positive transportation costs.

supply schedules, while D_f, D_{pp}, D_w, and D_r represent corresponding demands. The equilibrium retail price in this market is P_r, while prices at the several other stages are similarly determined in relation to the retail equilibrium quantity.

Equilibrium price in an isolated market is simply determined by equating the supply and demand functions in that market. In real situations, however, there ordinarily are many supplying areas and many markets, all of which

have at least potential effects upon each other. The quantity supplied by any producing area and the quantity consumed by any consuming area are therefore conditioned by the supply and demand functions of all other areas. These relationships may be illustrated with a simplified case involving two markets with individual supply and demand schedules. In isolation, these markets would arrive at independent equilibriums, but with trade, the price in each market would be influenced by the supply and demand of the other.

If transfer costs are ignored, a simple summation of supply and demand curves in the two markets would yield aggregate supply and demand relationships from which the equilibrium price for the combined markets could be

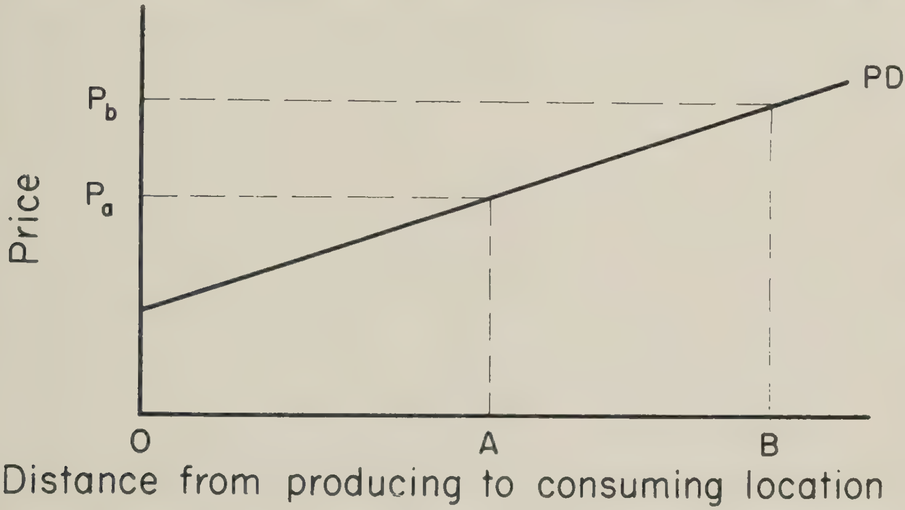

Fig. 7. Relationship of price to distance of consuming location from point of production.

determined. This price would always fall between the prices determined in the markets in isolation. The direction of product flow would be from the market of low to high isolation-market price. The export and import quantities could be determined by applying the combined market equilibrium price to the individual market supply and demand relationships.

A similar result occurs with the introduction of transfer costs. This is illustrated in the "back-to-back" diagram, figure 6, which portrays supply and demand relationships in two regions, A and B. The supply and demand functions of Region A are represented in conventional form, while those of Region B are reversed and positioned adjacent to the diagram for Region A. Transfer costs between the two regions are incorporated through the offset, T_{ab}, of the individual market diagrams. Because the flow of product would be from Region B to Region A (Region B is the low-price market) the Region B diagram is elevated so that any horizontal line of the back-to-back diagram indicates prices in the two markets that differ by exactly the unit costs of transfer, T_{ab}. "Excess supply" curves are plotted for each region by subtracting the amount demanded at any given price from the amount of regional supply at that price. The resulting curves show, in regard to price in both markets, the amount by which the regional supply exceeds regional

demand. The intersection of the two excess-supply curves equates the combined-market supply and demand functions of the two regions and specifies the combined-market equilibrium price as well as the amount of interregional product flow. This price is represented in figure 6 by NP_c in Region A and MP_c in Region B. The quantity shipped from Region B to Region A is ML, which is equal to both GF and DE. It is obvious that, if transfer costs are equal to or greater than the difference in market prices in isolation, trade will not occur. Prices in one region can differ from those in another region by an amount of plus or minus the transfer costs without giving rise to trade.

For a given exporting region, production plus transfer costs and product prices will, in the long run, differ among regions receiving a given product primarily as transportation costs differ. This is as shown in figure 7, where

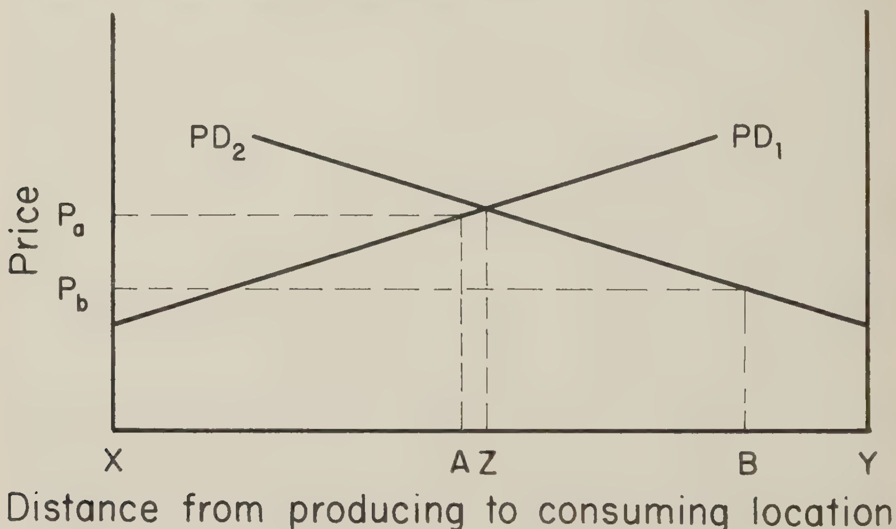

Fig. 8. Graphical determination of source and price for a consuming region.

delivered cost (equal to long-run price) increases as distance from producing region to consuming region increases. Thus, for Producing Region 1, product price is less in nearby Consuming Region A than in B. If there are alternative supply regions, however, this does not necessarily mean that price in Region B will exceed that in Region A. This is demonstrated with respect to a two-region supply source in figure 8, where PD_1 and PD_2 are the price-distance lines of Producing Regions 1 and 2. Consuming Regions A and B are located at distances of XA and XB from Region 1 and YA and YB from Region 2. Region A evidently will receive its product from Region 1 at price P_a and Region B will receive its product from Region 2 at price P_b if each supplying region has sufficient production capacity. Region 1 would supply any consuming area at distances up to XZ, and Region 2 would supply any consuming area up to distance YZ. At point Z the long-run price of product from Producing Regions 1 and 2 would be equal. In the short run, with supply already produced, transportation is the cost most significant to the production-consumption location relationship.

While a continuous transport cost-distance relationship is portrayed in figures 7 and 8, transportation rates—especially rail rates—are typically discontinuous. The long-run spatial price structure then is modified as in figure 9. In this diagram, the same transportation cost applies to all markets in the distance range O to A, another rate applies in the range A to B, and another from B to C. The relationship shown in figure 8 also is modified as in figure 10, where the same transportation rate applies over the distance range C to D from Producing Regions 1 and 2. In this situation, there is no difficulty in determining cost at any given distance from a given source. If, however, delivered cost from alternative sources is the same over a range of distance, the source of all product for a given market can no longer be identified uniquely. This effect is especially important when contiguous

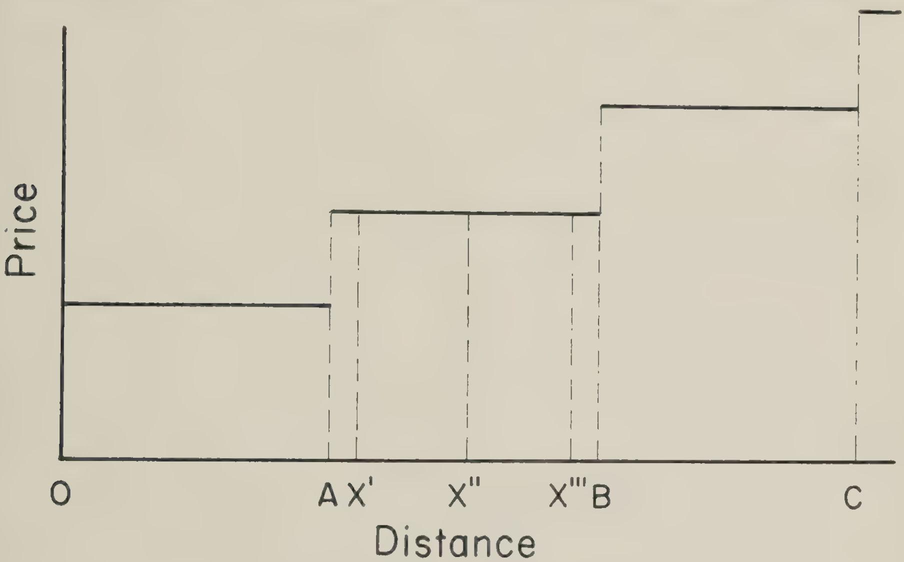

Fig. 9. Relationship of price to distance of consuming location from point of production, with discontinuous transportation rate structures.

producing regions ship over similar distances to remote markets, because zones of equal transportation cost usually become larger with increased distance. For instance, a single market at distances OX′, OX″, and OX‴ from three different supplying points would, as represented in figure 9, have the same transportation cost from each supply point despite the difference in distance to the market. If long-run cost in the different producing regions should be equal, the result is an area of indifference as to source of supply for this market.

With regional supply and demand functions given, the marketing area of a supply region is determined through an equilibrium involving transportation costs. This is graphically demonstrated in the upper section of figure 11. Nontransport costs, AC and BD, in the two regions are unequal. Unit transportation cost is the same for both producing centers. Total product cost, including transportation, increases as a linear function of distance to market.

With the simplifying assumption that transportation cost to any market point is a linear function of "air-line" distance from point of production, the loci of points of equal delivered costs from a given source form a system of concentric circles, called isotims, around the source. The market area for a supply point will consist of that area for which its delivered cost is least. The boundary between any two areas is formed by the locus of points at which delivered product cost from the two areas is equal. This is shown in the lower section of figure 11, where (x) and (y) are isotims of Producing Areas (1) and (2), respectively, and EF is the boundary between areas formed by the intersections of isotims of equal value. The market area of the region

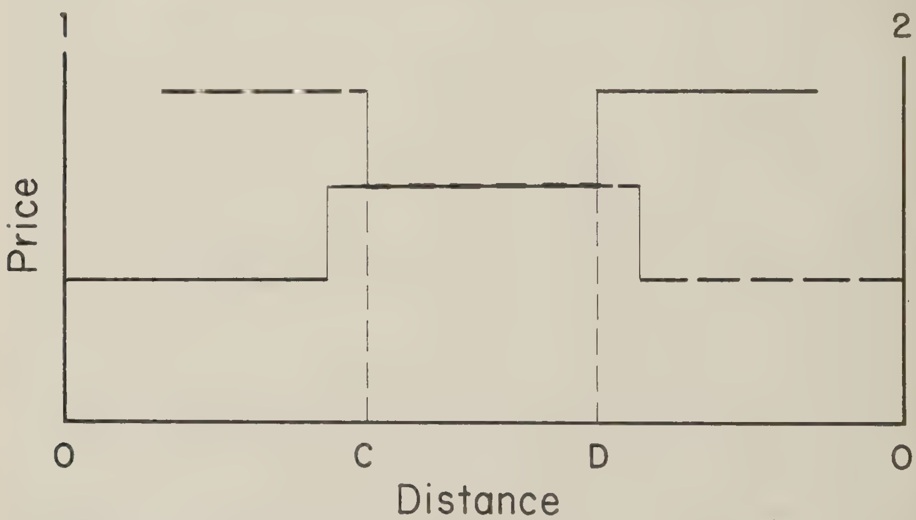

Fig. 10. Graphical demonstration of indeterminateness of supply source when discontinuous transportation rate structures result in equal costs from two supply sources.

of lowest nontransport cost is shown to be largest, with the boundary of equal delivered costs between regions bending around the supply region of higher cost. If nontransport costs were equal, the boundary of equal cost between these regions would be the perpendicular bisector of a straight line joining (1) and (2). If transportation cost increased with distance at a decreasing rate, the equal cost boundary would eventually envelop the region of highest nontransport cost.

To this point attention has been directed to the geographic structure of prices around producing centers and the allocation of consuming or market areas to those producing areas. A valuable characteristic of the allocation of production to consumption is that it results not only in efficient pricing but also in minimization of all costs entering the pricing analysis for all included markets. At point L in figure 11, as with any point on line EF, price is the same whether the product originates at (1) or (2). Consumers at any point not on line EF will receive their product from the producing point within the same market boundary, and price will be determined by producing-point long-run price and transfer cost. Point M represents any such point in the

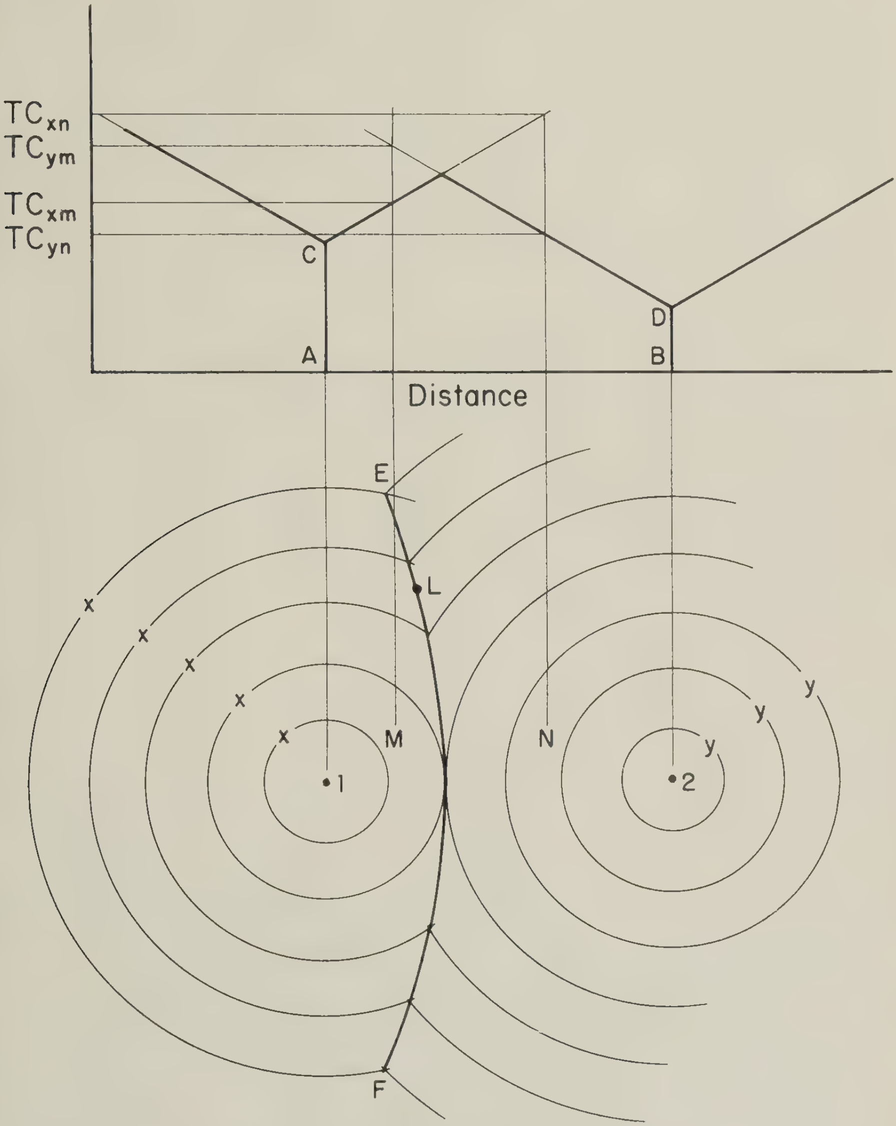

Fig. 11. Market area boundaries of supply regions of unequal nontransportation costs and equal transportation rate-distance functions.

market area of producing center (1) and N a similar point in the market area of producing center (2).

The effect of departure from this pattern is evident on consideration of the result if one unit of product from source (1) is assigned to N instead of M and one unit of product from source (2) is similarly assigned to M instead of N. The previously determined supply-demand equilibrium is thus maintained, while source of product for consuming locations is changed. If total costs are either unchanged or decreased by this reassignment, the

efficient-pricing allocation cannot also constitute a unique least-cost allocation. If total cost is necessarily increased by the reallocation, the solution of either a least-cost or efficient-pricing allocation is shown to solve simultaneously for the other.

Total cost changes resulting from the reassignment described above are:

For point M: $\triangle TC_m = TC_{2m} - TC_{1m} > O$,
for point N: $\triangle TC_n = TC_{1n} - TC_{2n} > O$,
total cost change: $\triangle TC_m + \triangle TC_n = TC_{2m} - TC_{1m} + TC_{1n} - TC_{2n} > O$,

where

$\triangle TC_m$ and $\triangle TC_n$ are the change in total cost of a unit of product delivered at points M and N, and the TC terms represent unit transfer costs. As any similar reassignment can likewise be shown to increase total costs, the efficient-pricing allocation is shown to be also a least-cost allocation.

This discussion has indicated the close relationship of efficient pricing and allocation processes in the long run. Through pricing, the aggregate value of the product is maximized; through allocation, the aggregate cost of that product to consumers is minimized. It has been shown that the solution of one of these problems also yields the solution of the other.

Linear Programming Framework

The graphic analysis given above is useful in presenting the basic problem of production and consumption in two regions. With several regions, however, mathematical rather than graphical treatment is required. With a continuous model such as described, this requires treating every point within the supply region as a point of origin for which all potential origin-destination combinations must be considered. This theoretically is possible, but necessary simplifications in empirical analyses often involve the assumption that all output of a given geographical region originates at a single point within the region. Demand or consumption destinations are similarly defined to be the demand or consumption of a geographical area concentrated at a point. This greatly reduces the number of origin-destination flows to be considered, with corresponding simplification of computations. While this means that a precise representation of the economic situation is not achieved, reasonably realistic approximations are possible.

In recent years, the mathematical technique of linear programming has been developed and has been widely applied to discontinuous, multiregional models.[6] In all linear programming problems, the concern is with either the

[6] Linear programming solution procedure is not presented here since there are many excellent sources, including: Robert Dorfman, P. A. Samuelson, and Robert M. Solow, *Linear Programming and Economic Analysis* (New York: McGraw-Hill Book Company, Inc., 1958); Earl O. Heady and Wilfred Candler, *Linear Programming Methods* (Ames: Iowa State College Press, 1958); and Saul I. Gass, *Linear Programming: Methods and Applications* (New York: McGraw-Hill Book Company, Inc., 1958).

Applications of the linear programming technique in empirical studies of spatial problems include: G. G. Judge, *Competitive Position of the Connecticut Poultry Industry, No. 7, A Spatial Equilibrium Model for Eggs*, Connecticut Agr. Exp. Sta. Bul. 318 (Storrs, 1956); W. R. Henry and C. E. Bishop, *North Carolina Broilers in Interregional*

maximization or minimization of some quantity. A useful aspect, known as the dualism property of linear programming, is found in the fact that, when linear programming is used to solve for either a maximum or minimum, the solution to the other can be obtained as a by-product. This is equivalent to the simultaneous solution of an efficient-pricing and least-cost allocation demonstrated graphically in the previous section. The dualism of pricing (maximization) and allocation (minimization) is a valuable property when linear programming is used to solve such problems. An example of the usefulness of the "duality" property is found in Henderson (1955). The interest may be in pricing only or in allocation only, but either problem can be approached, with one answer obtained directly and the other indirectly. Although the two problems are identical in form, there are often computational advantages in solving for one or the other. In the present study, the problem is approached from a cost minimization standpoint.

To place the problem in a linear programming framework, consider the relationship of two regions, such as A and B of figure 6, where it was found that, with trade in a given commodity, an amount ND would be produced in Region A, and MG in Region B; while NE would be consumed in A, and MF in B. The allocation of these previously determined regional productions to regional consumptions is to be solved. If, for convenience, subscripts 1 and 2 are used to designate Regions A and B, this may be expressed algebraically as follows:

$$\begin{array}{ll} \textit{Production} & \textit{Consumption} \\ P_1 = E_{11} + E_{12} & C_1 = E_{11} + E_{21} \\ P_2 = E_{21} + E_{22} & C_2 = E_{12} + E_{22} \end{array} \qquad (1)$$

where

P_i is the production of Region "i,"
C_j is the consumption of Region "j," and
E_{ij} is the production of Region "i" which is consumed in Region "j."

This information can be placed in matrix form, as in table 1.

Costs are introduced by applying appropriate data to each E_{ij} of the matrix. For the present, only transportation costs are considered. For any given interarea movement, they are assumed constant per unit transported and, regarding movements from Region "i" to Region "j," are designated as T_{ij}. These can be placed in a separate unit-cost matrix or combined with the production-consumption matrix to form a total-cost matrix as in table 2.

The linear programming problem to be solved is the determination of the non-negative E_{ij}, which minimize total transportation costs ($\Sigma_i \Sigma_j T_{ij} E_{ij}$) subject to the constraints that the total production of each region must

Competition, North Carolina Agr. Exp. Sta. Agricultural Economic Information Series No. 56 (Raleigh, 1957); M. M. Snodgrass and C. E. French, *Linear Programming Approach to the Study of Interregional Competition in Dairying*, Purdue Agr. Exp. Sta. Bul. S. B. 637 (Lafayette, 1958); S. Enke, "Equilibrium Among Spatially Separated Markets: Solution by Electric Analogues," *Econometrica*, 19 (1), January, 1951, 40–48; T. C. Koopmans and S. Reiter, "A Model of Transportation," in *Activity Analysis of Production and Allocation*, Cowles Commission Monograph 13 (New York: John Wiley and Sons, 1951); P. A. Samuelson, "Spatial Price Equilibrium and Linear Programming," *American Economic Review*, 62 (3), June, 1952, 283–303; K. A. Fox, "A Spatial Equilibrium Model of the Livestock Feed Economy in the United States," *Econometrica*, 21 (4), October, 1953.

TABLE 1

PRODUCTION-CONSUMPTION MATRIX

Region	Region 1	Region 2	Total regional production
1	E_{11}	E_{12}	$P_1 = \Sigma_j E_{1j}$
2	E_{21}	E_{22}	$P_2 = \Sigma_j E_{2j}$
Total regional consumption	$C_1 = \Sigma_i E_{i1}$	$C_2 = \Sigma_i E_{i2}$	$\Sigma_i \Sigma_j E_{ij}$

TABLE 2

TOTAL COST MATRIX

Region	Region 1	Region 2	Total transportation cost of regional production
1	$T_{11}E_{11}$	$T_{12}E_{12}$	$\Sigma_j T_{1j}E_{1j}$
2	$T_{21}E_{21}$	$T_{22}E_{22}$	$\Sigma_j T_{2j}E_{2j}$
Total transportation cost of regional consumption	$\Sigma_i T_{i1}E_{i1}$	$\Sigma_i T_{i2}E_{i2}$	$\Sigma_i \Sigma_j T_{ij}E_{ij}$

TABLE 3

TRANSPORTATION MODEL EXPORT IMPORT PROGRAM—DISTRIBUTION OF EXISTING SUPPLY

Producing regions	Consuming regions 1	2	. . .	m	Total regional production
1	E_{11}*	E_{12}		E_{1m}	$\Sigma_j E_{1j}$
2	E_{21}	E_{22}		E_{2m}	$\Sigma_j E_{2j}$
⋮					⋮
n	E_{n1}	E_{n2}		E_{nm}	$\Sigma_j E_{nj}$
Total regional consumption	$\Sigma_i E_{i1}$	$\Sigma_i E_{i2}$	. . .	$\Sigma_i E_{im}$	$\Sigma_i \Sigma_j E_{ij}$

* E_{ij} is the number of units transferred from Producing Region "i" to Consuming Region "j."
$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, m$

be allocated, and the total consumption specified for each region must be satisfied. The solution to this simple problem is immediately apparent: allocate local production to local consumption to the extent possible, and then ship from the surplus region to the deficit region. In a more general statement involving a larger number of regions, the production and consumption variables of the additional areas are added to the production and consumption equations (1), and the resulting equations are of the following form:

Production

$$\begin{aligned} P_1 &= E_{11} + E_{12} + E_{13} + \cdots + E_{1n} = \Sigma_j E_{1j} \\ P_2 &= E_{21} + E_{22} + E_{23} + \cdots + E_{2n} = \Sigma_j E_{2j} \\ P_3 &= E_{31} + E_{32} + E_{33} + \cdots + E_{3n} = \Sigma_j E_{3j} \\ &\;\;\vdots \\ P_n &= E_{n1} + E_{n2} + E_{n3} + \cdots + E_{nn} = \Sigma_j \mathrm{E}_{nj} \end{aligned} \tag{2}$$

Consumption

$$\begin{aligned} C_1 &= E_{11} + E_{21} + E_{31} + \cdots + E_{n1} = \Sigma_i E_{i1} \\ C_2 &= E_{12} + E_{22} + E_{32} + \cdots + E_{n2} = \Sigma_i E_{i2} \\ C_3 &= E_{13} + E_{23} + E_{33} + \cdots + E_{n3} = \Sigma_i E_{i3} \\ &\;\;\vdots \\ C_n &= E_{1n} + E_{2n} + E_{3n} + \cdots + E_{n3} = \Sigma_i E_{in} \end{aligned} \tag{3}$$

From equations (2) and (3) a total-cost matrix could be formed as in table 2. However, it is convenient at this point to redefine production of a given region to apply only to that part of regional production exported to other regions, and consumption of a given region to be only that part of total regional consumption imported. This is equivalent to applying zero transportation costs to intraregional flows, and is permissible because the interest centers only in the transportation costs of interregional flows.

To accomplish the separation into importing and exporting regions, the surplus production, F_i, of a given region is defined as,

$$F_i = P_i - C_i.$$

If F_i is positive, Region "i" is an exporting region and, if negative, it is an importing region. If F_i is zero (a remote possibility), Region "i" is removed from the equations because it is neither an importing nor exporting region. Production equations are redefined to apply only to exporting regions, and consumption equations are redefined to apply only to importing regions. Exporting regions are numbered from 1 to n and importing regions from 1 to m. An export-import matrix similar to table 1, and constructed from these equations, is given in table 3.

A similar formulation applies if production occurs in one set of locations and consumption in another, even though the two sets comprise the

same territory. The production locations are regarded as exporting regions, and the consuming locations as importing regions. This implies that all production is exported and that all consumption is imported, which is the model used in the present study.

TABLE 4
TRANSPORTATION MODEL UNIT
TRANSFER COST MATRIX

Producing regions	Consuming regions			
	1	2	. . .	m
1	T_{11}*	T_{12}		T_{1m}
2	T_{21}	T_{22}		T_{2m}
. . .				. . .
n	T_{n1}	T_{n2}	. . .	T_{nm}

* T_{ij} is the transfer cost of one unit of product from Producing Region "i" to Consuming Region "j."
$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, m$

The interregional transportation unit costs are summarized in table 4, where each entry indicates the cost of transporting one unit of product between the designated exporting and importing region. This matrix could be combined with table 3 to give a total-cost matrix as in table 2. However, it is customary to present them separately. In these tables, "*i*" refers to exporting regions, "*j*" refers to importing regions, and

(a) all T_{ij}'s are known and constant,
(b) $E_{ij} \geqq 0$,
(c) $\Sigma_i E_{ij}$ is specified for each "*j*,"
(d) $\Sigma_j E_{ij}$ is specified for each "*i*," and
(e) $\Sigma_i(\Sigma_j E_{ij}) = \Sigma_j(\Sigma_i E_{ij})$, that is, production equals consumption.

The problem to be solved is to minimize the total interregional transportation cost $(\Sigma_i \Sigma_j T_{ij} E_{ij})$ subject to the constraint that the total output of each producing region is allocated and the specified consumption of each consuming region is satisfied.

The Long-run Solution. In the short-run transportation problem, given regional supplies are allocated to fulfill given regional demands at minimum transportation cost. Since only transportation costs are considered in this solution, it is inadequate for determination of the efficient location of production in the long run—the objective of studies of interregional competition. The long-run problem requires determination of the pattern of regional production and the allocation of output to consuming regions that will minimize the total industry cost of production and distribution. While not universally applicable, the cost minimization criterion is widely applied in

this type of problem and is used here to define the "efficient" solution. It is evident that, in the long run, consumption and production *potentials* will be equal only by extreme coincidence. This means that equations (2) of the transportation problem outlined above must be assumed to become inequalities when applied to the long run. The inequalities can be transformed into equalities through creation of "fictitious" consuming regions similar to the "disposal activities" of some linear programming problems. (This type of modification does not, of course, apply only to long-run models. It could be used in a short-run model, for instance, to assign excess productive capacity of a group of factories to a "fictitious" market. The modification is introduced at this point because of its use in the long-run solution procedure of this study.) Equations (2) then become:

$$
\begin{aligned}
P_1' &= E_{11} + E_{12} + E_{13} + \cdots + E_{1m} + E_{1,\,m+1} \\
P_2' &= E_{21} + E_{22} + E_{23} + \cdots + E_{2m} + E_{2,\,m+1} \\
P_3' &= E_{31} + E_{32} + E_{33} + \cdots + E_{3m} + E_{3,\,m+1} \\
&\ \ \vdots \\
P_n' &= E_{n1} + E_{n2} + E_{n3} + \cdots + E_{nm} + E_{n,\,m+1}
\end{aligned}
$$

where

P_i' is the production *potential* of Region "i," and

$E_{i,\,m+1}$ is the portion of the production *potential* of Region "i" assigned to the "fictitious" consuming region.

An additional condition, $E_{i,\,m+1} \geqq 0$, must now be employed.

The fictitious region "m+1" will absorb all of the excess productive capacity of region "i." $E_{i,\,m+1}$ represents unused productive capacity of this region.

Equations (3) can be adopted without modification to represent consumption of actual consuming regions. One additional equation is needed in the set of consumption equations to represent absorption of unused production potential by the fictitious region. This equation is

$$C_{m+1} = E_{1,\,m+1} + E_{2,\,m+1} + E_{3,\,m+1} + \ \ldots\ + E_{n,\,m+1}$$

Table 5 is a modification of table 3, the basic transportation model export-import table, to include a fictitious consuming region, m+1, to absorb excess potential production. In table 5, the $\Sigma_j E_{ij}$ are redefined as potential regional production.

To determine the long-run production-consumption, export-import pattern, the total cost of supplying a unit of product from Producing Region "i" to Consuming Region "j" must be known. These costs will include production, processing, selling, and transportation costs, and are designated U_{ij}. Table 6 is a modification of table 4, and contains total unit costs for use with table 5 to solve the long-run production location problem. In this table, total unit costs, U_{ij}, are substituted for unit transportation costs, T_{ij}. Zero total unit costs are assigned to the imports of the fictitious region.

TABLE 5

TRANSPORTATION MODEL EXPORT-IMPORT PROGRAM MODIFIED TO ABSORB EXCESS POTENTIAL SUPPLY BY A "FICTITIOUS" CONSUMING REGION

Producing regions	Consuming regions					Total regional production
	1	2	. . .	m	m + 1	
1	E_{11}*	E_{12}		E_{1m}	$E_{1,\ m+1}$	$\Sigma_j E_{1j}$
2	E_{21}	E_{22}		E_{2m}	$E_{2,\ m+1}$	$\Sigma_j E_{2j}$
. . .						. . .
n	E_{n1}	E_{n2}		E_{nm}	$E_{n,\ m+1}$	$\Sigma_j E_{nj}$
Total regional consumption	$\Sigma_i E_{i1}$	$\Sigma_i E_{i2}$	. . .	$\Sigma_i E_{im}$	$\Sigma_i E_{i,\ m+1}$	$\Sigma_i \Sigma_j E_{ij}$

* E_{ij} is the number of units of product produced in Region "i" for consumption in Region "j."

$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, m + 1$

TABLE 6

TRANSPORTATION MODEL TRANSFER CHARGE MATRIX MODIFIED TO INCLUDE PRODUCTION, PROCESSING, AND DISTRIBUTION COSTS

Producing regions	Consuming regions				
	1	2	. . .	m	m + 1
1	U_{11}*	U_{12}		U_{1m}	$U_{1,\ m+1}$
2	U_{21}	U_{22}		U_{2m}	$U_{2,\ m+1}$
. . .					. . .
n	U_{n1}	U_{n2}	. . .	U_{nm}	$U_{n,\ m+1}$

* U_{ij} is the total cost of production, processing, selling, and transfer of one unit of product from Region "i" to Region "j."

$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, m + 1$

In tables 5 and 6,

(a) all U_{ij}'s are known and constant,

(b) $U_{1,\,m+1} = 0$, $U_{2,\,m+1} = 0, \cdots, U_{n,\,m+1} = 0$, because they represent costs for *unused* production *potential*,

(c) $\Sigma_i E_{ij}$ is specified for any "j,"

(d) $\Sigma_j E_{ij}$ is specified for any "i," and

(e) $\Sigma_i(\Sigma_j E_{ij}) = \Sigma_j(\Sigma_i E_{ij})$, that is, production potential equals consumption including that of the fictitious region.

The problem to be solved with the aid of tables 5 and 6 is determination of the minimum total cost of production, processing, selling, and transportation ($\Sigma_i\Sigma_j U_{ij}E_{ij}$) subject to the constraint that total potential production is equal to total specified consumption including that of the fictitious consuming region.

Adaptation of the Theoretical Model

In idealized terms, the foregoing presents a framework for study of the spatial economy of a given industry. The logical framework stresses the role of market prices and transfer and production costs in the allocation of regional production among different markets and in the allocation of resources among alternative uses within given producing regions. A computational model is presented in which linear programming procedures for solution of the "transportation problem" are adapted for the inclusion of production and transfer costs.

A logical basis for analysis is provided in a long-run setting, where demand functions explain the effect of price on regional consumption; and supply functions similarly explain supply response to market prices at the several levels of production and distribution. While empirical analysis in these terms is much to be desired, demand and supply functions in the form needed usually are unavailable or cannot be developed with the means at hand. This is true in the present study of the location of strawberry production, and the development of useful approximations to the supply and demand functions is therefore an essential step in the empirical investigations of this industry. The nature of these approximations is explained in succeeding sections of this report.

DESCRIPTIVE BACKGROUND

The empirical analysis of interregional competition in the production and processing of frozen strawberries begins with a descriptive study of production trends and regional characteristics with respect to this industry. In this the close link between the fresh and processed markets is recognized, although major interest is in processed berries.

Trends in Total Production

Total annual strawberry production in the United States was relatively stable during the 1920's and early 1930's. It decreased somewhat during the mid-1930's and recovered to previous levels just before World War II. Production during the war period decreased drastically, dropping over 45 per cent from 1942 to 1943 and nearly 30 per cent from 1943 to 1944. Since 1946, however, production has gradually increased (fig. 12). Total

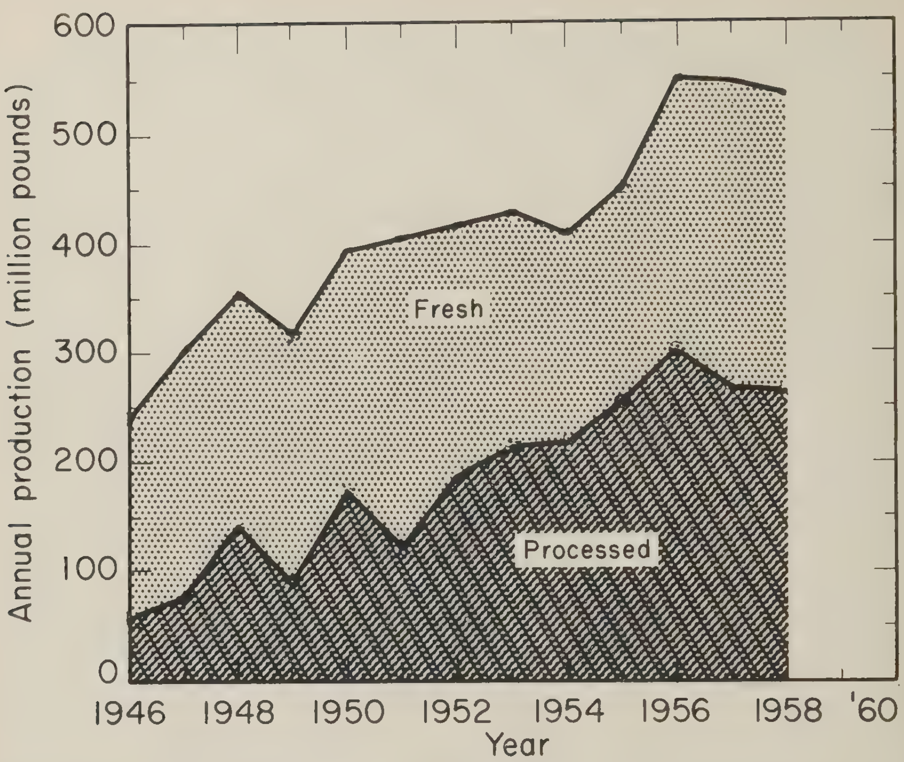

Fig. 12. Annual strawberry production in the United States, 1946–1958. Source: U.S. Agricultural Marketing Service, *Marketing California Strawberries, 1955 Season* and *1958 Season* (San Francisco: Federal-State Market News Service, April, 1956, and May, 1959).

production in the 11-year period, 1946–1957, has increased by 295,000,000 pounds, or 115 per cent. The 1955 production was nearly equal to that of 1942 and only slightly below the record heavy volume of 1929. Both 1956 and 1957 set new records for strawberry production.

Total strawberry output is used in two major categories—fresh and processed. Postwar production growth has been mainly in processed output. This has expanded by almost 350 per cent since 1946 as compared with a 50 per cent growth in the production of berries for fresh use. Most of the growth in processed output occurred in the production of frozen strawberries which now account for 85 to 90 per cent of the total.

Regional Production Patterns

Study of competitive relationships among different regions requires their geographic definition, and is aided by recognition of particularly significant characteristics of given localities. The regional composition selected, production trends, per acre yields, and harvest seasons—considered to be especially important regional characteristics—are described below.

Regional Composition. In this study, the United States was divided into the 10 production regions shown in figure 13. Mexico was defined as a sup-

Region	*States included*
1	New York, Pennsylvania, Connecticut, Massachusetts, Maine
2	Michigan, Ohio, Indiana, Wisconsin, Iowa
3	Virginia, North Carolina, South Carolina, Maryland, Delaware, New Jersey
4	Tennessee, Kentucky, Illinois
5	Arkansas, Missouri, Oklahoma, Kansas
6	Florida
7	Louisiana, Texas, Alabama
8	Washington
9	Oregon
10	California

Fig. 13. Ten geographical regions used in the analysis of strawberry production.

plementary region to permit consideration of imports from that country. These regions were selected to define separate areas of relatively concentrated production and to include in each region contiguous areas of minor production. The geographic extent of the region thus defined does not indicate the volume of actual production, nor is the location of major producing centers within regions specified. Major production centers are roughly indicated in figure 13, however, by listing first, for each region, the state that contains the primary production center of that region. The grouping used is logical, although many alternatives to that selected are possible.

Production. Not all regions of the country have shared equally in the recent production increases—some have even decreased. This is shown in figure 14 for the period since 1946. Regions 3, 4, 5, 6, and 7 (roughly the southeastern quarter of the United States) have declined in total strawberry production through this period, although the trends in Regions 4 and 6 are not pronounced. Regions 1 and 2 have had small average annual increases in total production. Major increases have occurred only in Regions 8, 9, and 10—the Pacific Coast states. Figure 14 also indicates the influence

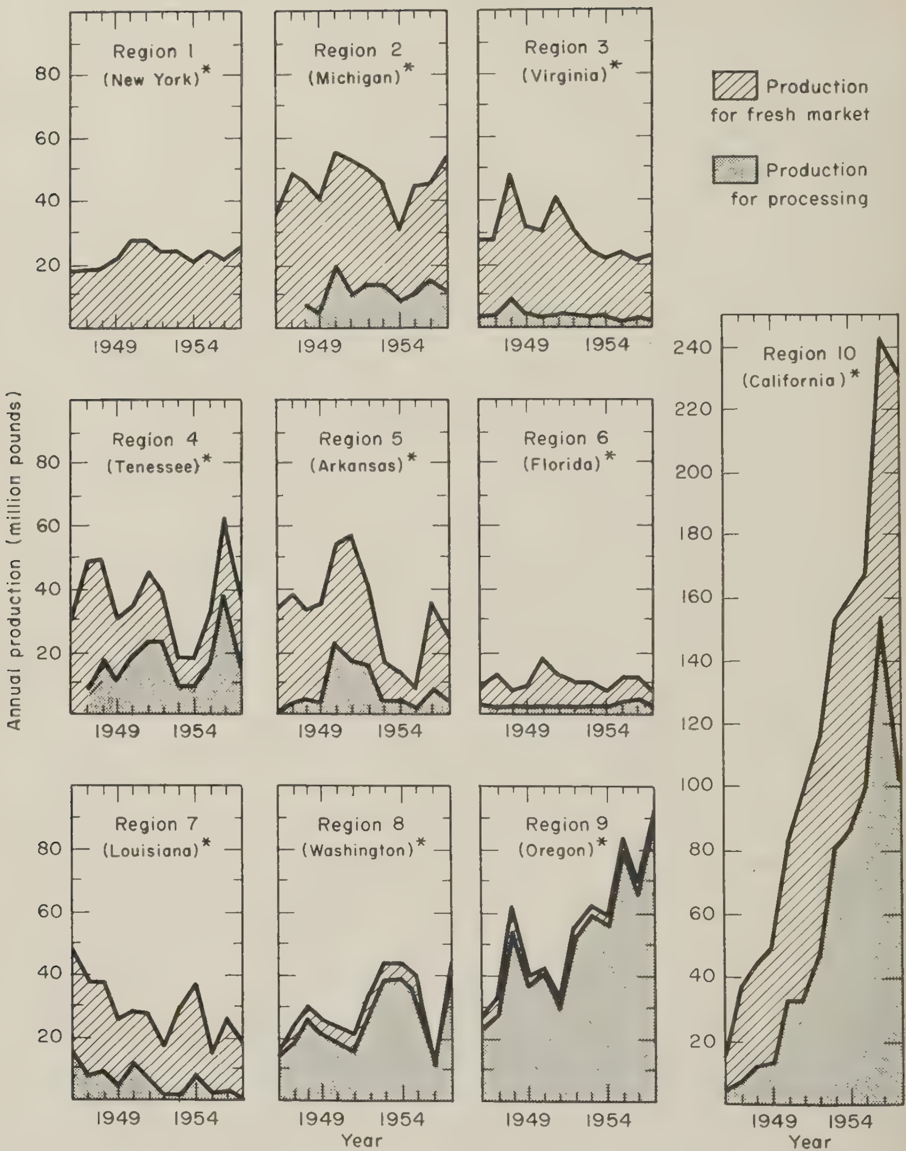

Fig. 14. Annual strawberry production by producing region, 1946–1957. Asterisks (*) indicate the principal producing state in each region. Output totals shown, however, are for entire region as identified in figure 13.

of processing on the growth of the strawberry industry. With the minor exception of Region 1, increases in total annual output have occurred only in regions producing a large volume of processed strawberries. This is especially evident in Regions 8 and 9, which produce almost exclusively for processing. Region 10 (California), on the other hand, has rapidly increased production for both the fresh and processing markets.

Yield per Acre. Total production changes reflect the joint effects of changes in total acreage and yield per acre; and acreage changes are often due, at least in part, to the cost-changing influence of yield changes of previous years. Figure 15 compares the yields per acre of the first and last halves of the postwar period, 1946–1957. In this figure, the bar on the left for each region represents the average yield per acre for the years 1946 through 1951, while the bar on the right shows the average for the years

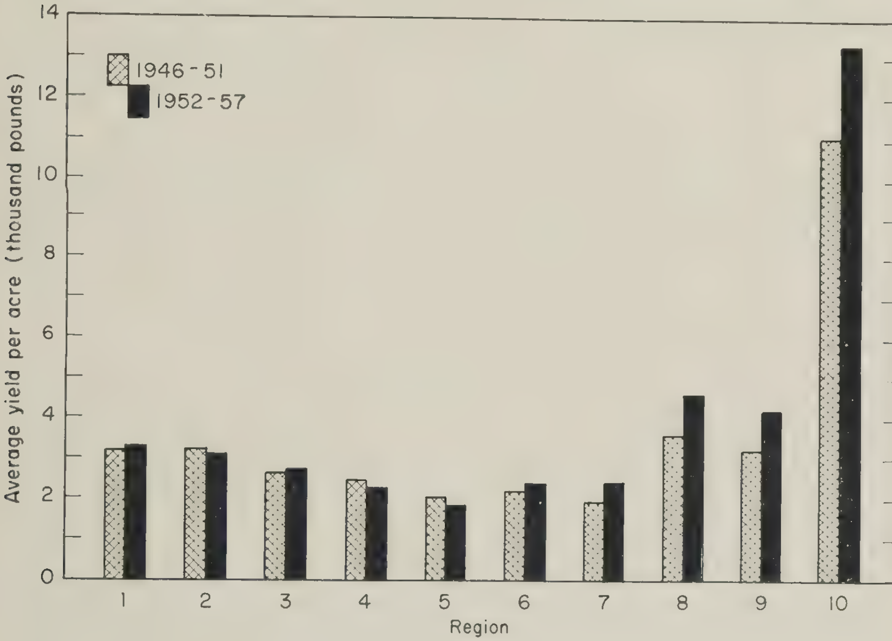

Fig. 15. Comparisons of regional average strawberry yields in the years 1946–1951 and 1952–1957.

Source: Years 1946–1948, *Marketing California Strawberries, 1955 Season,* table 20. Years 1949–1957, *Marketing California Strawberries, 1957 Season,* table 24. These tables were compiled from reports of the Agricultural Estimates Division, Agricultural Marketing Service, USDA, Washington, D.C.

1952 through 1957. Only Regions 8, 9, and 10—the same regions having recent large increases in total production and production for processing—have experienced large increases in yield per acre. At the same time, Regions 2, 4, and 5, the only other areas in which processing has been important to the strawberry industry of the region, have had slightly decreasing average yields and have failed to show much increase in quantities processed. Although presently available evidence is not adequate for relating yield and quantity processed, the obvious inference is that increased yields of Regions 8, 9, and 10 may have decreased unit costs in comparison with other regions and so given them a competitive advantage in the processing market.

Harvest Season. The regional harvest season is important in two respects: date of harvest and length of the harvest period (fig. 16). Region 6, with a production period extending from mid-December through April, has a

strong potential as a supplier of fresh markets. This is true also of Region 7, in which the harvest season runs through April to mid-May, and Regions 3, 4, and 5, in which the season extends from mid-April to mid-June. In Regions 1, 2, 8, and 9, the season extends through May, June, and July. The latter harvest period, and location near large consuming centers, gives special advantage to Region 1 in the marketing of fresh berries during the late spring and early summer months. This is also true of Region 2, although a substantial quantity of strawberries in Region 2 is frozen. Great distance from major fresh markets not pre-empted by Region 10 gives potential importance to Regions 8 and 9 primarily in the production of processed berries. In Region 10, the 11-month harvest season (January to November) makes this area a competitor in the marketing of both fresh and processed berries.

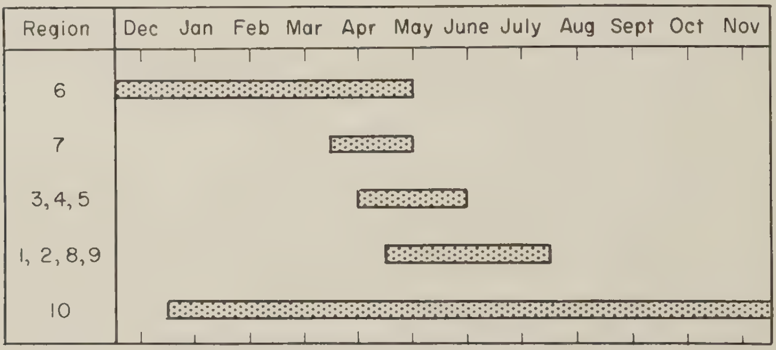

Fig. 16. Usual strawberry harvesting seasons, by region.

While date of harvest is of primary importance in production for the fresh market, length of season is significant largely with respect to production and processing costs. A long season is usually, although not necessarily, accompanied by greater yields per acre than is a short season; in this, the 11-month season in California is outstanding. If labor must be imported, a long season makes it easier to obtain that labor supply and helps to spread fixed labor procurement costs over a larger crop. Finally, a long harvest season enables a processing plant to spread fixed expenses over a larger output and to adopt investment-increasing but average-cost decreasing techniques which would not be profitable if the plant operated only a few weeks each year. Some of these benefits are obtained through integrated use of the labor force and processing plant for other products, thus spreading fixed costs over quantities of other products rather than over a larger volume of strawberries. This practice is widely followed. Nevertheless, a long producing season for strawberries must be counted a major advantage for Region 10.

Approach to Empirical Analysis

The regional production pattern described briefly above and a regional consumption pattern—developed later—are tangible elements of the framework of interregional competition previously described in theoretical terms. The trends noted in regional production and in the relative importance of

the fresh and processed markets suggest the possibilities of further shifts in the competitive relationships among different regions. These relationships and their effects on the location of strawberry production are subjected to empirical study in the remainder of this report.

The consumption pattern is developed by defining each state—excluding Hawaii and Alaska—and the District of Columbia as separate consuming regions. For details, see page 567.

REGIONAL PRODUCTION AND TRANSFER COSTS

Transfer costs are defined as including all costs other than farm production and delivery to the processing plant, that is, processing, storage, transportation, wholesaling, and retail distribution.

Long-run regional supply and demand functions of the type specified in the theoretical framework developed earlier are not easily estimated, and their development is well beyond the resources available in this study. However, useful approximations appropriate to the circumstances of strawberry production and distribution are possible. These are presented in the following sections.

Long-run Regional Farm Supply Price

Historical information on which to base a statistical analysis of regional supply response to strawberry prices is available only for a relatively short time period. Moreover, these data are of little value in making such estimates because recent technological changes in strawberry production have rendered obsolete the input-output relationships on which the production response of past periods was based.

An alternative approach is to attempt farm-budget estimates of long-run cost at various levels of regional output and involving the use of efficient production techniques. Estimated long-run cost in relation to regional output might then be taken as an indication of expected long-run supply-price relationships. One of numerous difficulties in this procedure is, however, immediately apparent—namely, that factor prices in such budgets must be developed on the basis of opportunity costs. Since these are established in terms of competition for use of the regional resources in the production of alternative products, a solution for a single crop requires simultaneous consideration of all significant alternative resource uses.

In an important respect, however, the budgeting problem is simpler than suggested above because the supply prices for many productive services used in farm production—for example, for tractors and fertilizers—are determined in a broad national market and so may be assumed to be unaffected by local shifts among alternative crops. This is not true, however, for the basic resource, land, and in some situations for labor and other factors. With regard to these "local" inputs, a possible assumption—and one used in the empirical analyses of this study—is that all, including land, are priced relative to each other as they would be in long-run equilibrium and that these prices reflect returns which could be obtained from alternative uses.

Restricting consideration of opportunity costs as suggested above still leaves an estimating problem of great difficulty. It was not surmounted in this study, and an even more drastic simplification was accepted. This is

that regional supply functions for strawberries are highly elastic and that for practical purposes they are perfectly elastic within the relevant range in likely output for a given region. Under this assumption, estimated long-run costs for efficiently organized production at a commercial scale were obtained for each region, and these costs were taken as the supply price for the relevant output range of that region.

The simplified procedure used departs radically from the theoretical supply-price relationships and from the type of supply response frequently observed in practical situations where long-run price changes are expected to accompany adjustments in output. This reflects the assumption that output expansion would lead ultimately to intensification on some fixed factors already in use and to the introduction of less well-adapted or higher-priced resources. The reverse would apply to reduction in output. This tendency is recognized in the production of strawberries, but special circumstances with respect to this crop make the assumption of perfect elasticity over the relevant range in likely regional output a plausible and useful simplification.

In terms of land requirements, for example, strawberries require a very small percentage of total cropland in the United States. In fact, total current processed output in this country probably could be produced in any one of the present major regions without requiring substantial diversions from land use in other crops. In California, for example, processed output in 1958 amounted to 133.5 million pounds in a total United States output of 263.8 million pounds. With an average 1958 yield of 12,800 pounds per acre, this output required approximately 10,500 acres of California farm land. Production of the total United States processed volume of 263.8 million pounds in California would have required an addition of about 10,000 acres in this crop. A shift of this magnitude would not be expected to have a significant effect on the opportunity cost for land.

While labor might also be a limiting factor in some areas, considerable flexibility in labor supply exists in most regions—for example, through use of transient and vacation-period labor and, in some regions, through the importation of foreign nationals under labor contract.

The simplified approach used is further supported by the fact that strawberry production does not require highly specialized land resources, and by recent technological developments in strawberry production. In California, for example, these include a new variety, the Solana, which is currently being introduced in commercial production. There is reasonable promise of high yield per acre and high quality with this variety, and preliminary indications of its adaptability for processing use.[7] Its cultural requirements are less restrictive than those for some varieties now in commercial production, and it appears likely that Solana can be grown successfully outside the relatively cool, midcoastal areas now the major source of California process berry production. It is suitable, however, only for summer planting. Another innovation is the recent development of economical techniques for control of Verticillium wilt. Pressures for new land to escape the effects of wilt, therefore, may be eliminated or greatly reduced.

[7] Of new plantings in 1959 in the southern coastal area of California, approximately 10 per cent is reported to be of the new Solana variety. For production possibilities with this variety see R. S. Bringhurst and Victor Voth, "Summer Planted Solana Berries," *California Agriculture* 13 (4), April, 1959, 6.

The potential for some—if not all—of the above *types* of development is present in all regions, and this adds to the plausibility of the assumptions made here in empiric approximations of long-run strawberry supply prices.

Regional supply prices on the above basis were estimated for 1958, using factor prices appropriate for each region. These estimated costs for 1958 were taken as the best available indication of regional long-run supply price.

Estimating Procedure and Results

Most of the basic information used in the preparation of the budget estimates of long-run production cost was obtained through group interviews conducted with a small number of producers in each region. This involved development of a consensus as to the production process, yield, and harvest

TABLE 7

ACREAGE, PLANTING LIFE, AND EXPECTED YIELD ON TYPICAL COMMERCIAL STRAWBERRY OPERATIONS IN SELECTED REGIONS OF THE UNITED STATES, 1958

Region	State	County	Typical acreage for harvest	Usual bed life (harvest years)	Expected average annual yield (pounds per harvested acre)
1	New York	Erie and Chautauqua	10	1	5,667
2	Michigan	Berrien	5	2	6,233
2	Michigan	Manistee	10	2	8,000
3	Virginia	Accomac and Northampton	20	2	4,533
4	Tennessee	Cumberland	6	3	3,740
4	Tennessee	Macon	6	3	4,080
4	Tennessee	Madison	6	3	3,400
5	Arkansas	White	4	3	2,153
6	Florida	Hillsborough	2	1	5,357
7	Louisiana	Tangiapahoa	4	1	3,400
8	Washington	Whatcom	12	3	9,000
9	Oregon	Yamhill	7	3	10,057
10	California	Monterey and Santa Cruz	20	3	22,800
10	California	Stanislaus	15	2	10,000

characteristics of the region, and local factor prices. The interviewer acted only to guide the discussion and record conclusions. The data thus obtained were used to estimate the types, quantities, and costs of labor, equipment, and materials required in production by a "representative" producer. A representative producer for this purpose was defined in terms of prevailing conditions as to acreage per grower, production practices, and yields.

Only a summary of results in the study of regional production costs is given here. For more detail, see Dennis (1959).

Location of Studies. Although 95 per cent of the frozen strawberry production is concentrated in five states, and over 85 per cent is in three states, production costs were studied in all sections of the country to determine their potentials as competitors in this market. Group interviews were conducted in the states of Washington, California, Arkansas, Louisiana, Florida, Virginia, New York, and Michigan. Detailed cost study results for a group of Oregon producers were utilized to determine costs for that state, and recently obtained individual interview data were utilized in Tennessee.

TABLE 8

STRAWBERRY PRODUCTION COSTS PER ACRE FOR LABOR, MATERIALS, OVERHEAD, AND HARVESTING IN SEVERAL MAJOR PRODUCING AREAS OF THE UNITED STATES, 1958*

Region	State	County	Establishment to first harvest			Annual between-harvest expense‡			Annual overhead per bearing acre			Total nonharvesting cost per bearing acre§	Harvest cost per bearing acre	Total cost per bearing acre
			Labor	Materials	Miscellaneous†	Labor	Materials	Miscellaneous†	Interest on investment	Depreciation, repair, and upkeep of buildings and machinery	Miscellaneous (taxes, licenses, office etc.)			
			dollars											
1	New York	Erie and Chautauqua	92	183	—				56	38	13	382	400	782
2	Michigan	Berrien	149	153	10	44	15	9	35	21	13	259	570	829
2	Michigan	Manistee	72	182	7	37	57	9	45	108	10	345	575	920
3	Virginia	Accomac and Northampton	39	104	—	6	43	—	28	11	2	137	434	571
4	Tennessee	Cumberland	144	56	—	92	14	—	10	7	3	157	279	436
4	Tennessee	Macon	159	91	—	60	13	—	14	10	3	159	315	474
4	Tennessee	Madison	115	65	—	5	15	—	16	12	3	104	314	418
5	Arkansas	White	184	99	—	13	21	—	13	9	4	143	216	359
6	Florida	Hillsborough	156	184	62				54	74	5	535	810	1,345
7	Louisiana	Tangiapahoa	269	67	—				25	48	19	428	356	784
8	Washington	Whatcom	206	230	38	81	71	—	58	96	36	431	424	855
9	Oregon	Yamhill	‖									313	665	978
10	California	Monterey and Santa Cruz¶	712	457	150	309	104	106	48	157	172	1,163	1,026	2,189
10	California	Stanislaus	378	230	247	209	48	89	22	22	25	669	673	1,342

* For detailed analysis, see C. C. Dennis, *The Location and Cost of Strawberry Production*, University of California, Giannini Foundation of Agricultural Economics, Mimeographed Report No. **217** (Berkeley, 1959).

† Composed primarily of charges for custom work, including both labor and materials; includes land rental in California. Dashes indicate that no miscellaneous expenses are included in the cost estimates of those areas.

‡ "Annual between-harvest expense" appears only for those areas typically having two or more harvest years from a given planting.

§ Includes "annual overhead per bearing acre" and weighted average of "establishment to first harvest" and "annual between-harvest expense." For instance, if two harvest years are obtained, it includes "annual overhead per bearing acre" plus one half of the "establishment to first harvest" cost and one half of the "annual between-harvest expense." If three harvest years are obtained, it includes "annual overhead per bearing acre" plus one third of the "establishment to first harvest" cost and two thirds of the "annual between-harvest expense."

‖ Cost component composition of the Oregon study differs from those of other studies, so only total cost is given.

¶ Additional studies are now being conducted in this region.

Factors Affecting Production Costs. The production cost study of each area was analyzed in detail to determine each component of total production cost and to indicate how costs are affected by regional differences, such as the following:

(1) *Life of Planting.* Planting life is recognized to vary considerably within a given region, but no effort was made to determine the effect of such variation on regional production cost. Estimates as to "usual" planting life were used in the regional cost calculations.

(2) *Acreage.* The strawberry acreage of individual producers within a given area may vary considerably, but most of the production typically occurs on plantings within a comparatively small acreage range. Estimates as to representative acreage per grower in each region, given in table 7, range from 2 acres per grower in Florida to 20 acres per grower in Virginia and California.

(3) *Yield.* Perhaps the most crucial estimate made is the expected yield. It is notable that in every case the estimated yields given in table 7 are higher than the area averages for the six-year period, 1952-1957, given in figure 15. The yield estimates obtained in the group interviews, however, are based on the practices for which costs were estimated. These costs are intended to be representative of the yields attained by typical commercial producers, rather than the average of all producers of the area, and are considered appropriate for use in the estimation of long-run cost.

(4) *Investment per Bearing Acre.* One of the determinants of production cost, although of less importance than might be expected, is the investment required per acre of bearing strawberries. This includes investment in buildings, equipment, land, and planting. Land investment per bearing acre was determined by dividing the total investment in land devoted to strawberries by the number of bearing acres. Thus, in an area where plantings do not bear during their first year, but have two bearing years, the nonbearing year is divided between the two bearing years and the investment per acre is one and one-half times the estimated per acre land value. In California production the representative grower was reported to rent rather than own land; a rental charge was therefore substituted for investment cost. With regard to equipment and buildings, the total investment required for the representative acreage was estimated. Since some of the facilities included were ordinarily used for other products, an allocation proportional to expected use with the different products was made. The allocated portion was then divided by the number of acres of bearing strawberries to obtain the estimated investment per acre.

(5) *Direct Labor.* While mechanization is generally employed where applicable, operations such as hoeing, weeding, and harvesting still require large amounts of hand labor. The labor costs of these operations varied, among regions, from 16 to 68 per cent of total nonharvesting expense. Part of this range is due to regional differences in methods of performance of the field jobs. Other important factors are the range in wage rate, from 50 cents to $1.50 per hour, for field labor; and—since greater mechanization was found on the larger units—acreage

per grower. In those cases where a large part of the labor is furnished by the operator and his family, the direct labor charge represents the major area of cost flexibility in that a smaller wage may be accepted, at least in the short run, to enable continued production. If most of the labor is hired, this flexibility is not available. Most of the direct labor, however, is involved in harvesting, which in most areas occurs over a few weeks at most, and an operator and his family can furnish this labor for only very small operations.

TABLE 9

ESTIMATES OF HARVEST, NONHARVEST, AND TOTAL STRAWBERRY PRODUCTION COSTS PER POUND IN SEVERAL MAJOR PRODUCING AREAS OF THE UNITED STATES, 1958*

Region	State	County	Cost per pound		
			Harvest	Nonharvest	Total
			cents		
1	New York	Erie and Chautauqua	7.1	6.7	13.8
2	Michigan	Berrien	9.2	4.7	13.9
2	Michigan	Manistee	7.2	4.3	11.5
3	Virginia	Accomac and Northampton	9.6	3.0	12.6
4	Tennessee	Cumberland	7.5	4.2	11.7
4	Tennessee	Macon	7.7	3.9	11.6
4	Tennessee	Madison	9.2	3.1	12.3
5	Arkansas	White	10.0	6.7	16.7
6	Florida	Hillsborough	15.1	10.0	25.1
7	Louisiana	Tangiapahoa	10.5	12.6	23.1
8	Washington	Whatcom	4.8	4.7	9.5
9	Oregon	Yamhill	6.6	3.1	9.7
10	California	Monterey and Santa Cruz	4.5	5.1	9.6
10	California	Stanislaus	6.7	6.7	13.4

* Computed from yield and cost estimates given in tables 7 and 8.

Total Production Costs. The total cost of producing strawberries is composed of two major parts—harvesting and nonharvesting. Nonharvesting expenses can be further divided into the cost of bringing a new planting to its first harvest and the cost involved in caring for the planting from one harvest to the next. The direct cost of labor and materials used in each of these categories, the overhead cost, and harvesting cost are given in table 8 for each of the areas studied. The total cost per bearing acre is the sum of these costs.

Total nonharvesting cost per bearing acre as given in table 8 is the sum of all except harvesting costs. "Overhead per bearing acre" is a fixed annual cost regardless of number of harvest years. "Establishment to first harvest" is the variable cost incurred to bring the strawberry planting to the first harvest, and "annual between-harvest expense" is the cost incurred in caring for the planting from one harvest to the next. If only one harvest is obtained from a planting, the total nonharvesting cost is the sum of "annual overhead per bearing acre" and "establishment to first harvest" costs. If second or third harvests are obtained from a planting, the cost of care of the planting from one harvest to the next enters the cost calculations. If the planting bears

two years, the second year overhead cost remains the same as for the first bearing year, but the total cost for the first bearing year differs from the second year; that is, the second bearing year would cost the sum of "annual overhead per bearing acre" and "annual between-harvest expense." The average costs per bearing acre would be the average of the costs of the first and second years. This could be found directly by taking the sum of the "annual overhead per bearing acre," one-half of "establishment to first harvest"—which applies to one-half of the bearing years—and one-half of the "annual between-harvest expense"—which also applies to one-half of the bearing years.

If a planting yields three years, the average annual nonharvesting costs will be the sum of the "annual overhead per bearing acre," one-third of the "establishment to first harvest costs"—because this cost is incurred in only the first of three harvest years—and two-thirds of the "annual between-harvest expense," a cost incurred in the last two of the three harvest years.

Harvesting costs presented in table 8 are for processing berries (caps removed) and would need adjustment before being applied to fresh market berries. This adjustment would consist primarily of a picking differential—because the caps are not removed from fresh market berries—and an adjustment in the container charge. The harvest cost includes picking (including housing and transportation of pickers), supervision, hauling the product to market, and a container charge, where applicable. Harvest costs per acre are shown to be equal to or greater than nonharvest costs in all except two of the areas studied.

Unit Production Costs. Production cost per pound, based on the costs given in table 8 and yields of table 7, are given in table 9. The production costs of Florida and Louisiana only seem to be so high as to appear obviously noncompetitive in the frozen strawberry market on the basis of production costs alone. These areas are presently strong only in the fresh market, and are able to enter that market because of their early production season. Even that advantage is somewhat weakened by the availibility of frozen strawberries—a substitute for fresh—during their harvest season.

Washington, Oregon, and the Monterey-Santa Cruz area of California have a definite cost advantage, all three having total costs of 9.7 cents per pound or less, while the next lowest costs (of Manistee, Michigan) are 11.5 cents. The next eight of the 14 areas studied fall within a 2.5 cents-per-pound range in production costs, but the remaining three areas are considerably higher.

Long-run Regional Processing Costs

Regional differences in costs of processing strawberries for freezing, while not so large as regional differences in farm production costs, are often of sufficient magnitude to swing the balance of production advantage in terms of total cost from one region to another. Determination of regional processing cost was therefore given considerable emphasis in this study. As at the level of farm supply, an approximation of the theoretical supply-price relationships for processing services was developed in terms of estimated long-run costs. These, for the purposes of this study, are defined as the level of total cost attainable with current factor prices and techniques in plants efficiently

organized to produce a specified output. The estimates used are based on detailed studies in California strawberry processing plants, the results of which are adapted to reflect cost relationships in other regions.

California Processing Costs

The costs of processing strawberries for freezing were synthesized in economic-engineering studies based on observation of actual processing operations. This involved consideration of alternative techniques in the performance of individual operations and, for specified outputs, the selection of the particular combination of such alternatives that would minimize total cost.

The basic data were obtained in intensive studies of seven California strawberry processing plants, ranging in capacity output rate from 7,500 to 25,000 pounds per operating hour. In these plants, time and production studies were made of particular jobs and machine operations. In addition, accounting records and interviews with management and supervisory personnel were obtained to provide further information as to labor utilization and output, machine capacities, general expense categories, and factor prices. Similar data (Reed, 1959) obtained in 10 plants processing Lima beans for freezing provided additional information in regard to certain cost components. Data concerning equipment costs and performance characteristics were obtained from several major equipment manufacturers, local equipment fabricators, and contractors.

Only a brief summary as to the type of plant cost study and results is given here. For details, see Dennis (1958). The methodology of the processing plant studies is described by French *et al.* (1956).

The use of these data in the development of production standards for the various categories of labor and equipment, and in the synthesis of least-cost plants, is explained briefly below.

Labor Standards. A production standard was developed for each of the direct labor jobs performed in strawberry processing. These standards are designed to represent the continuous output rate which an average worker could attain with relatively full use of his total work time. The standards represent neither the average nor the best output rate observed in actual plant operation. A check against actual performance rates indicates that they lie between these limits. In the development of these standards, time and production studies, where applicable, were used to determine the amount of net working time required to perform a given job. To this an allowance of 15 per cent of total work time was added to cover nonproductive time such as unavoidable delay, scheduled rest periods, and personal time. This was taken as the gross unit time from which potential output rates per hour were computed. Accounting record data also were utilized to determine job standards in those categories, such as sorter and utility labor, where time and production studies are not well adapted.

The number of workers required for each job in relation to rate of output was then determined on the basis of one worker for each multiple and additional fraction of the applicable job standard. Current wage rates were applied to these requirements to determine hourly labor cost with respect to work method used and plant capacity.

Equipment and Building Requirements. Estimates of capacity output

rates for individual equipment units were developed on the basis of plant observations, interviews with plant management and supervisory personnel, and the specifications of manufacturers. These capacity rates were used in determining the number of equipment units required with a given technique and plant size. The estimated quantities were converted to investment costs through application of unit equipment costs consisting of quoted prices of manufacturers plus sales taxes and installation costs. The latter include the costs of electrical service and connections to primary water lines. If price differences in regard to given types of equipment were found, the lowest price of equipment capable of accomplishing the desired objective with comparable efficiency was used. And with each technique considered, the lowest cost combination of equipment required for a given output rate was selected.

Investment in the buildings required for plants of given capacity rate was calculated in two steps. First, the type of structure and amount of floor space required for equipment, access aisles, storage, office, and service areas were estimated through analysis of equipment and building layouts in the plants studied. Engineering estimates of construction cost then were made, based on the quantities of building materials and construction labor required and on current (1958) materials prices and wage rates.

Plant Stage Costs. The various process steps in preparing strawberries for freezing can be visualized from the floor plan and equipment layout for a representative California plant given in figure 17. Raw product is received and stored near the dumping area and later transported to the point where the field crates are emptied into a conveyor to a shaker-washer. From this point the product flows through quality sort and size-grading equipment, where it is divided into "sortouts" and two forms of packed berries—whole and sliced. The berries for sliced pack continue through slicing and sugaring equipment to filling stations. The carton-type pack is cased in fiberboard boxes. These, as well as the berries packed in 30-pound tins, are palletized and transported by fork truck to an adjacent freezing facility. Supplemental operations include the stacking and reloading of empty field crates, the receipt and handling of supplies such as sugar and package materials, the forming of cases, and miscellaneous operations.

In this analysis, it is convenient to consider the total process in terms of groups of activities defined as "plant stages" (see French *et al.*, 1956, p. 545). The concept is similar to that described in Brems (1952). Each such stage consists of closely coordinated operations, the output of which is the raw-material input of a succeeding stage. The output of the final stage (or final stages, if the product flow is subdivided into two or more categories) is the output of the plant. The definition of each stage is largely a matter of convenience and logic. However, if plant total costs are to be obtained by simple summation of costs within individual stages—as in this analysis—each stage must be so defined as to be, for practical purposes, independent in terms of costs. This permits comparison of costs with alternative techniques to be made within each stage.

Separate plant stages were defined as follows: (1) dumping; (2) quality sorting and size grading; (3) slicing and the sugaring system; (4) container filling; (5) casing; (6) receiving, checkout, and in-plant transportation of products and materials; (7) miscellaneous equipment and materials; (8)

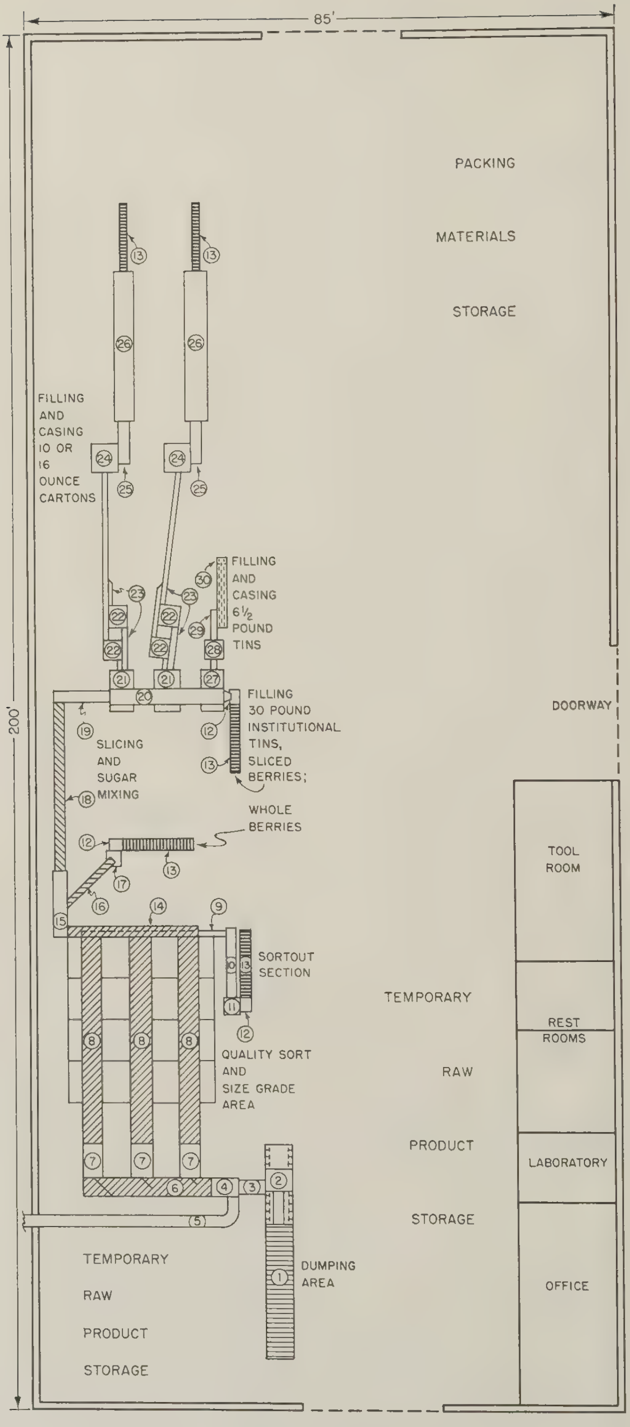

Fig. 17. Floor plan for a representative, medium-sized strawberry processing plant. California, 1958.

supervisory and miscellaneous labor; (9) office and administrative expense; and (10) building costs. The final operation—freezing—usually is independent of the other operations and often is performed by an independent firm on a contract basis. For this reason, the freezing operation is not included in the processing cost analysis but is introduced in a later section as a per unit cost incurred for custom service.

Within each of the operating stages defined above, performance standards with respect to individual jobs or units of equipment were used to estimate physical requirements with respect to labor, equipment, electric power, and other services as affected by the methods used and capacity rate of plant output. Appropriate wage rates and prices for power and other variable services as well as for equipment were applied to these estimated physical requirements to determine, for each stage and technique, the variable cost per plant hour and the total investment required in equipment and buildings. With this total investment, an annual charge was computed—including allowances for depreciation, interest on the investment, fixed repair expense, insurance, and taxes. Within-stage total annual cost with a specified output rate was then estimated as the annual fixed charge, plus total season variable cost—the latter computed as variable cost per hour times hours operated per year, or per harvest season.

With respect to each stage technique, total season cost in each plant stage was computed for several different lengths of season and at each of a series of closely spaced output rates. Selection of the technique of lowest cost in the set of estimates pertaining to a given season length and output rate then defines the long-run technical organization and long-run total season cost associated with particular values as to rate of output and length of season. From selected points over the whole range of output rates and season lengths considered, cost functions were developed for each stage. These relate within-stage total season cost to the appropriate output variable and length of operating season.

The coefficients of stage cost functions developed as above with respect to each plant operating stage and cost component are summarized in table 10. The stage and cost-component equations in this table are segregated according to the volume category—that is, whether raw product or packed—on which they are based. Those components which do not vary with the form of the final product are based on the quantity of raw product processed (quantity dumped) and are grouped in the table as "common costs." The "slicing and sugar mixing" stage is also on a raw product basis, but applies only to sliced berries. The second section of this table contains those cost components that are based on quantity of output (pounds packed) of each of the products considered in this report.

An individual equation is read from this table by applying the multipliers in the table to the variable in the subheading. For instance, the cost equation for the dumping stage is:

$$TSC = 111 + 108.8(I) + 197.2(H) + 38.9(I)(H)$$

in which TSC is the total season cost in dollars, (I) is the thousands of pounds of plant hourly raw product capacity, and (H) is the hundreds of hours of annual plant operation. The multipliers of this equation appear in the first line of table 10.

TABLE 10

SUMMARY OF COST FUNCTIONS FOR COST COMPONENTS AND STAGES IN PLANTS PROCESSING STRAWBERRIES FOR FREEZING CALIFORNIA, 1958*

A. Cost Categories Based on Input (Raw Product) Capacity

Cost category	Variables†				
	(C)	(I)	(H)	(I) (H)	(I) (H) (Q)
	cost multipliers				
Common costs:					
Dumping	111	108.8	197.2	38.9	
Quality sort and size grade	343	85.6	190.0	186.8	10.43
Sugar supply	784	115.0	26.0	3.6	
Receiving, checkout, etc.	664	237.0	122.0	44.9	
Miscellaneous equipment	1,072	9.2	32.5	1.3	
Miscellaneous labor	2,800	.....	711.0	124.0	
Administration	.....	.....	.....	551.0	
Building	1,070	307.7			
Total	6,844	863.3	1,278.7	950.5	10.43
Slicing and sugar mixing	335	44.0	14.0	1.6	

B. Cost Categories Based on Output (Packout) Capacity

Cost category	Variables†			
	(C)	(P)	(h)	(P) (h)
	cost multipliers			
10-ounce cartons, 24 per case:				
Filling	488	587	355	83.3
Casing	475	343	232	94.0
Total	963	930	587	177.3
16-ounce cartons, 24 per case:				
Filling	488	367	332	55.7
Casing	281	234	294	64.0
Total	769	601	626	119.7
6½-pound tins, 6 per case:				
Filling	1,133	291	221	56.4
Casing	40	28	281	106.4
Total	1,173	319	502	162.8
30-pound tins, sliced berry:				
Filling	169	...	179	114.0
30-pound tins, whole berry:				
Filling	204	22	205	123.1

* Taken from C. C. Dennis, *An Analysis of Costs of Processing Strawberries for Freezing*, University of California, Giannini Foundation of Agricultural Economics, Mimeographed Report No. **210** (Berkeley, 1958), p. 55.

† The cost equation variables are as follows:

C = A constant cost which is incurred regardless of length of season or size of plant.
I = Plant-input capacity in thousand pounds per hour (thousand pounds dumped).
H = Hundred hours of plant operation.
Q = Per cent of berry input that must be removed by quality sort labor. It includes sortouts and rots.
P = Packout capacity of the particular cost category in thousand pounds per hour.
h = Hundred hours of operation of the particular cost category.

Likewise, the equation for all costs applying to any form of product (total common costs) is:

$$TSC = 6{,}844 + 863.3(I) + 1{,}278.7(H) + 950.5(I)(H) + 10.43(I)(H)(Q)\,; \quad (4)$$

the equation giving the additional costs of the slicing and sugaring operation is:

$$TSC = 335 + 44.0(I) + 14.0(H) + 1.6(I)(H)\,; \qquad (5)$$

the equation giving the additional costs which apply *only* to 10-ounce cartons packed 24 per case is:

$$TSC = 963 + 930(P) + 587(h) + 177.3(P)(h)\,; \qquad (6)$$

while the additional costs which apply *only* to whole-berry 30-pound tins are given by the equation,

$$TSC = 204 + 22(P) + 205(h) + 123.1(P)(h). \qquad (7)$$

Season Total Plant Cost. Since the various plant stages have been defined to be, for practical purposes, independent in terms of costs, total long-run season cost for plants producing given outputs can be computed simply by summing values computed from equations such as the above. Consider, for example, a given plant which has a raw product input capacity of 15,000 pounds per hour, operates 1,000 hours per year, processes berries of such quality that 5 per cent of the berries must be removed as sortouts (packed as whole berries in 30-pound tins) and 5 per cent rots (a total of 10 per cent removed from the inspection belt), uses a berry-sugar ratio of 4 to 1, and packs 10-ounce cartons of sliced strawberries. The cost components for this plant, based on raw product input, are the combination of the "common costs" and "slicing and sugar mixing," given by equation (4). Cost components related to packed output rate are given by equation (5). Substitution directly in equation (4) gives an estimate of total season cost for components related to raw product amounting to \$190,891, while equation (5) gives the cost of slicing and sugar mixing at \$1,375. Equation (6), however, requires computation of packed output on the basis of raw product flow, sortout per cent, and berry-sugar ratio. If, as in this example, 10 per cent of the berries are removed from the inspection belt, and the berry-sugar ratio is 4 to 1, the 15,000 pounds per hour raw product input is reduced to 13,500 pounds of berries, while 3,375 pounds of sugar are added, making a total output of 16,875 pounds per hour. Using this figure as the output volume, total season cost is found from equation (6) as \$52,446. In calculating the final cost component —packing the sortout volume (5 per cent of raw product input) in 30-pound tins—the packed volume in this category is first adjusted for the addition of sugar. With a berry-sugar ratio of 4 to 1, 750 pounds of berries, plus 188 pounds of sugar, are packed per hour (a total of 938 pounds per hour) and the total season cost for this rate of output is given by equation (7) as \$3,430.

The total plant cost is the total of all of these costs.

Common costs	\$190,891
Slicing and sugar mixing	1,375
10-ounce cartons, 24 per case	52,446
Sortouts	3,430
Total	\$248,142

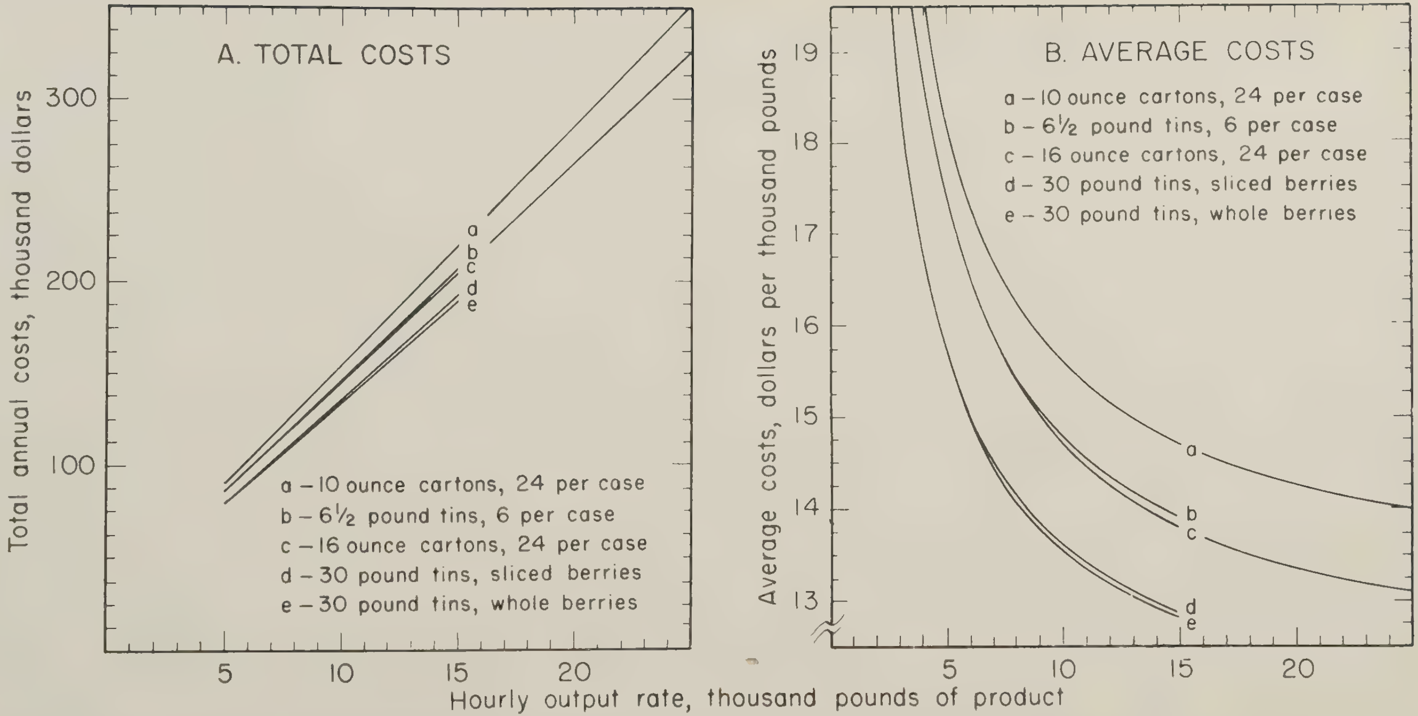

Fig. 18. Total and average long-run costs of packing various products in single-product plants processing strawberries for freezing—costs based on output poundage, a 1,000-hour operating season, 10 per cent of the berry input removed from the inspection belt, and a 4-to-1 berry-sugar ratio. California, 1958.

Average Total Cost. Cost per unit is found by dividing total annual cost by the number of pounds processed, expressed either in terms of pounds of raw product input or packed product output. With input rate given, packout rate is determined by berry quality and the amount of sugar added to the berries. This has been demonstrated in the above example where 15,000 pounds of hourly berry input became 16,875 pounds of hourly packout. Average cost per 1,000 pounds, on an input basis, in this case, is $16.54 ($248,142 divided by 15,000), and on a packout basis is $14.70 ($248,142 divided by 16,875).

Using the cost equations as described above, the total season cost can be estimated for any specified situation—plant size, length of operating season, berry quality, berry-sugar ratio, and product (or products). However, each of these cost determinants must be specified in advance to allow this cost calculation.

Variables Specified. In the analysis described above, certain simplifying assumptions and specifications were made. These are considered unlikely to have an important effect on cost. They are summarized as follows:

1. Plant size is defined in terms of the number of quality inspection belts used. The capacity per belt is 5,000 pounds of raw product per hour.
2. A capacity rate equal to or exceeding that of the inspection belts is provided at all other plant stages.
3. Packed product is limited to Grade A sliced and Grade B whole strawberries. (The effect of this limitation is confined largely to the sorting labor requirement and costs.)
4. California processing plants normally operate at night to minimize the delay between picking and processing. Therefore, the 1958 union wage scale for night shift work is used. It is assumed that no work is required that involves premium overtime wage rates.
5. With uniform operation with respect to output rate in any given plant, variation in daily volume is attained by changes in hours worked per day. Since the union contract agreement requires payment for a minimum of four hours on any day worked, it is assumed that sufficient raw product is received to require at least four hours of capacity operation.
6. Freezing and selling costs were not considered in the analysis and are therefore omitted from the cost relationships given at this point.
7. The cost of sugar per pound of processed berries in any given plant is a constant, dependent upon the berry-sugar ratio and whether the sugar is purchased in bags or in bulk. This cost is not included, but can be easily computed from the current price. Bulk purchase of sugar is assumed.
8. Packing materials cost is governed by the type of product. This cost is not included, but would add a constant amount per pound depending upon the container used.
9. The cost of land suitable for processing facilities varies widely and is, furthermore, difficult to determine. To avoid the use of land prices which apply to a specific area, and an unnecessary limitation of the area of applicability of this study, this cost is also omitted.

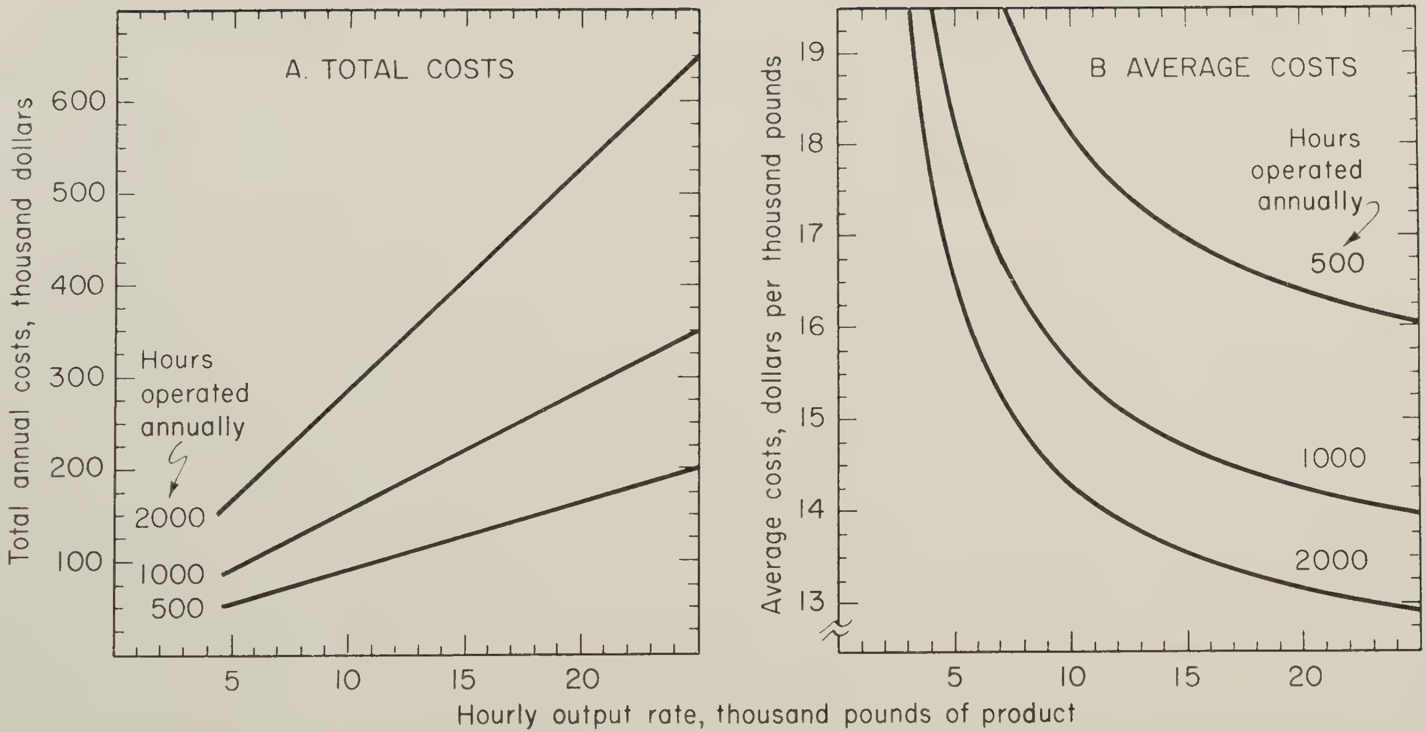

Fig. 19. Effect of length of season on total and average long-run costs in plants processing strawberries for freezing in 10-ounce cartons, 24 per case—costs based on hourly output poundage, a 1,000-hour operating season, 10 per cent of the berry input removed from the inspection belt, and a 4-to-1 berry-sugar ratio. California, 1958.

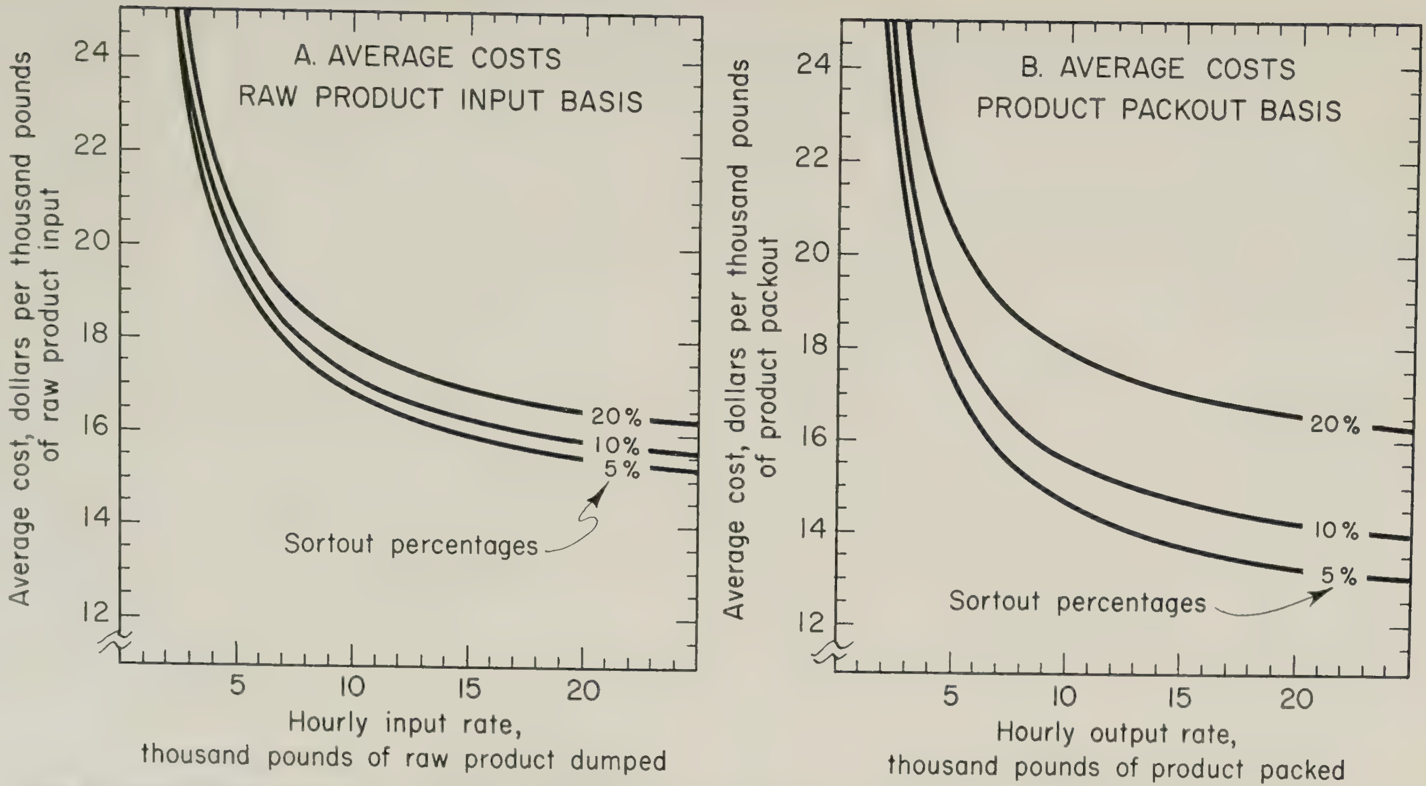

Fig. 20. Effect of raw product berry quality, as indicated by per cent of berries removed from inspection belt by quality-sort labor, on average long-run costs in plants packing strawberries for freezing in 10-ounce cartons, 24 per case—costs based on a 1,000-hour operating season, a 4-to-1 berry-sugar ratio, equal quantities of rots and sortouts, and either (A) input poundage (raw product dumped) or (B) output poundage (product packout). California, 1958.

Variation in Cost Determinants. From the stage-cost equations given in table 10, it is evident that season total and average unit costs are strongly influenced by the values assigned to cost-determining variables such as type of package, rate of output, hours operated per season, and per cent of sort-outs. Since these variables are likely to take on different values in different regions, it is useful to consider the nature of their effect on unit costs.

(1) *Products packed and plant size.* Total season costs for the five different forms of packed berries are shown for a 1,000-hour season and in relation to packed output rate in figure 18. Panel B of figure 18 expresses these total costs in terms of average costs per 1,000 pounds of product packed. These curves are the long-run cost curves—total and average—for plants packing any one of the products shown under the conditions specified. They show that packing in larger containers tends to result in a lower processing cost per pound and that average costs decrease very rapidly with increased plant size in the lower ranges of plant size, but less rapidly as plant size becomes greater. This decrease in average cost as plant size increases is due to more effective use of certain components—such as buildings, equipment, and supervision—and the substitution of various cost-reducing techniques in the larger plants.

(2) *Length of operating season.* Many fixed and partially fixed elements of cost either do not vary or do not vary proportionately with the number of hours operated. A longer processing season spreads these costs over a greater output with a resulting decrease in unit costs. Figure 19 demonstrates the effect of the number of hours operated annually on total season and average unit costs, using 10-ounce cartons as the example. This figure shows that, while there is an appreciable decrease in the cost per pound as length of season increases, most of this decrease comes in the shorter seasons. The effect is progressively smaller as season length increases.

(3) *Strawberry quality.* Berry quality, as measured by the quantity of berries that must be removed from the inspection belt by quality-sort labor, affects total and unit processing costs in two ways. Poor berry quality, for example, increases the costs of sorting a given quantity of raw product; but with the accompanying reduction in packed volume, the total costs of filling and casing are reduced. Costs per 1,000 pounds processed increase, of course, as the proportion of sort-outs increases. This effect is especially noticeable if unit costs are based on packed output rate since, to obtain a given rate of packed output, increasing quantities of raw product must be run as the proportion of rots and sortouts increases. These effects are illustrated in figure 20, which gives average unit costs in relation to both input rate and output rate.

(4) *Production in multi-output plants.* The term "multiple output" is applied here to production of the same basic product—strawberries—in several different forms. "Multiple-product" plants referred to elsewhere in this report are those in which the output consists of essentially different products, for example, strawberries and Lima beans. In the foregoing sections, attention has been confined to consideration

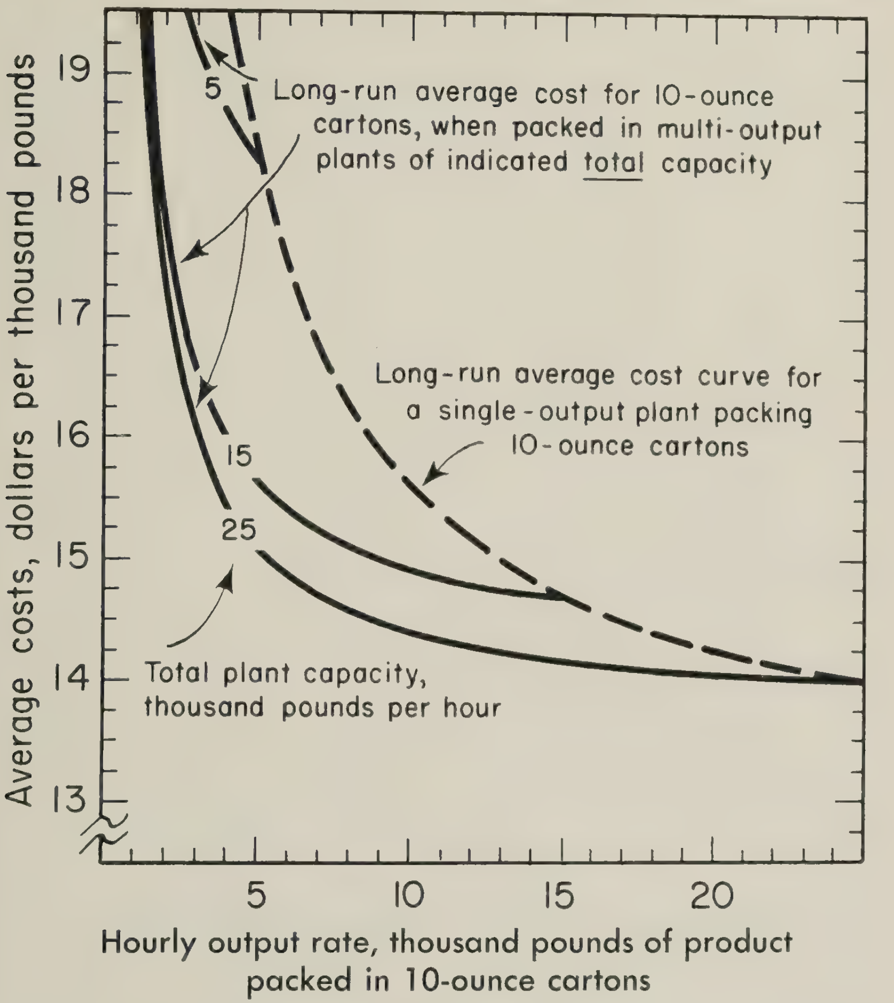

Fig 21. Long-run average costs of packing 10-ounce cartons of frozen strawberries in a single-output plant, as compared with packing this container as part of the total output of a multi-output plant. The example given applies to 10-ounce cartons packed 24 per case, with a 4-to-1 berry-sugar ratio and involving 10 per cent sortout and a 1,000-hour operating season.

of plants planned to pack only one of the several types of strawberry containers in common use. The usual practice, however, is for a given plant to produce two or more forms of packed output. The effect of this is to reduce the costs of any one of the several forms packed in comparison with the cost level in a single-output plant of corresponding output rate. A plant packing only 10-ounce cartons, for example, at a rate of 15,000 pounds per hour faces higher unit costs than does a multi-output plant with this capacity in 10-ounce cartons, plus output in other containers amounting to 5,000 pounds per hour—making total

plant output rate 20,000 pounds per hour. This is because the common-cost components—that is, those related to total raw-product input—enter into the cost calculations with the scale associated with 20,000 pounds-per-hour capacity and the economies of this scale are reflected in lower total unit cost for the 15,000 pounds per hour, 10-ounce-carton output, than would result in packing this volume in a single-output plant of that capacity rate.

The nature of this difference is illustrated in figure 21, which presents unit costs in relation to the capacity rate of output in a plant having 10-ounce cartons as its basic output. Unit costs of packing 10-ounce cartons in plants planned for this single output are shown in relation to capacity output rate by the dashed curve. This curve, for example, shows unit costs with 10,000 pounds-per-hour capacity output rate to be about $15 per 1,000 pounds packed. Lower unit costs are indicated by the solid curves if this same volume of 10-ounce cartons is packed in plants of larger total output rate, a portion of which is in other types of containers. Thus in a plant of total output rate of 15,000 pounds per hour—comprised of 10,000 pounds per hour in 10-ounce cartons and 5,000 pounds per hour in other type containers—the estimated unit cost of the 10-ounce carton pack is slightly under $15 per 1,000 pounds. With a total plant output rate of 25,000 pounds per hour, the 10-ounce carton cost is still lower, amounting to slightly under $14 per 1,000 pounds packed.

The example given in figure 21 applies specifically to the operating conditions stated, and involves an arbitrary allocation of the "common costs" to the various types of output in proportion to the volume packed in each type of container. While other operating conditions and other rules for allocating the common costs would give slightly different results, the principle demonstrated in figure 21 would still hold.

Alternative "rules" for allocating the common costs to the different forms of packed output might involve their division in proportion to value of the different outputs, hours of labor expended on each, and so on.

Regional Processing Costs

Processing cost relationships for the producing regions defined in figure 13 (p. 523) were developed through appropriate adjustment in the basic relationships established for California plants. This required consideration of regional differences in factor prices and length of processing season and their effect on choice as to economical technique. The necessary adjustments were made on a stage-by-stage basis for each region, using the basic physical requirements determined for California plants and adjusting costs in accordance with regional differences in factor prices. In general, labor standards developed in the studies of California plants were applied in other regions to jobs utilizing the same methods regardless of plant location. While some reservations apply to this procedure because of possible differences in labor and management efficiency due to the considerable differences in length of operation season among regions, the importance of this influence is considered

small. This is related to "learning" or "progress" response to increased experience. For discussion of this, see Hirsch (1952) and Asher (1956). With few exceptions, the jobs encountered in strawberry processing are simple and require relatively short periods of training and experience for development of full proficiency.

In a few instances, techniques not observed in California plants were found in general use in other areas. The bases for establishing production standards with respect to these methods are described below. With respect to this problem, as well as other aspects of the cost adjustments, only the general nature of the procedure used and a summary of results are given.

TABLE 11

ESTIMATED REGIONAL BASE WAGE AND ELECTRICAL POWER RATES, APPLICABLE TO STRAWBERRY PROCESSING PLANTS, 1958

Region	Principal producing state	Regional factor prices	
		Base wage	Electrical power charge
		dollars per hour	*cents per kwh*
1	New York	1.00	1.6
2	Michigan	1.00	3.3
3	Virginia	1.00	3.2
4	Tennessee	1.00	1.1
5	Arkansas	1.00	3.6
6	Florida	1.00	3.6
7	Louisiana	1.00	3.6
8	Washington	1.55	1.1
9	Oregon	1.55	1.2
10	California	1.80	2.5

Factor Price Adjustment. Of the factor prices considered in adjusting California costs to other regions, wage rates are most important. The relationship among regional wage levels in strawberry processing is shown in a general way in table 11 in terms of base wage rates—that is, the wage rate for the lowest paid category—for male workers. In Regions 8, 9, and 10 these are established by union-company agreements, but in other regions the minimum wage established by law is the effective base wage. Where labor is unionized, wage rates are available by job category for skilled and experienced laborers, but in other regions these wage scales are not established. In the Northwest, union wage scales representing several cities in the processing area were obtained, and an average of these was used to estimate wage rates for those regions. In all other regions, only the base wages were sufficiently definite to use as representative of the region. Wage rates for jobs not usually performed at the base wage were established for these regions in the same ratio to the California wage rates as the regional base wage was to the California base wage.

Regional processing costs were also adjusted for regional differences in power charges. Estimated rates based on information supplied by power com-

panies in each region are given in table 11. These rates are proportionately much higher in some regions than in others, the highest unit charges being more than three times as much as the lowest unit charges. Power charges, however, while apparently large in absolute terms, are a small part of total costs. Therefore, a large percentage change in this cost can result in only minor change in unit processing cost.

The delivered price of each piece of equipment used in strawberry processing was estimated on the basis of f.o.b. manufacturing plant prices and cost of delivery to each region. Since strawberry processing equipment manufacturers are located in several areas of the nation, no region has a large advantage with respect to transportation costs. Installed prices for individual equipment items, therefore, differ only slightly from region to region.

Length of Processing Season. Strawberries, being very perishable, must be processed promptly after harvesting, to avoid deterioration. They cannot be stored for later processing, and the maximum length of processing season is dictated by the length of harvesting season.

Expected annual hours of processing were established, by region, from estimates of local processing plant managers. These estimates are based on the past experience of those managers, and do not necessarily represent full-time operation throughout the harvest period. Thus, in Regions 3 to 7, inclusive, the normal processing season length is estimated at 150 hours. This is less than could be attained on the basis of length of harvesting season because most of the early strawberries are marketed fresh, and strawberries are processed only when the fresh market weakens. The length of processing season, therefore, depends upon the strength of the fresh market, and is quite variable from year to year. Since it appears likely that the fresh market will continue to take the berries harvested early in the year in these regions, the estimate given is considered appropriate.

The estimate of season length for Regions 1, 2, 8, and 9 is 200 processing hours per year, and for Region 10 it is 1,000 hours per year. The fresh market is not a major factor in determining the length of processing season in these regions, although it is of some importance in Regions 1 and 2. Some processing plants in each of these regions, however, now process during the majority of their respective harvesting seasons.

Processing Techniques. The preparation of strawberries for freezing involves much the same process, regardless of location. The process flow and equipment layout indicated in figure 17 may, therefore, be regarded as representative of the organization of strawberry processing plants in general, although specifically applicable to California plants. Different methods may, however, be employed for particular operations, depending on such local conditions as factor prices, length of processing season, and local customs and institutional arrangements. In general, processing cost equations for each region were developed on the basis of the requirements as to physical input rates determined in the California studies, but involving the use of prices applicable to the particular area. Exceptions are as follows:

(1) *Dumping.* California processors receive strawberries in flat crates of approximately 14 pounds capacity, but in most plants outside the western states the field container consists of a quart measure such as

commonly used for fresh market berries. Managers in these areas generally recognize the high labor requirements of dumping quart containers as compared with field crates. Objections to use of the crate, however, are raised on the ground that processing represents a minor part of the strawberry market and producers are reluctant to accept a special container for that market; that the disappearance rate of field crates would be exceptionally high for any plant which attempted to introduce them; and that their cost would not be warranted for the short processing season, especially in view of producer opposition.

Estimates by plant managers of the quantity of berries that could be dumped, per man hour, from quart containers under relatively good conditions were obtained and used as a basis of estimating dumping labor requirements where use of quart containers is prevalent. A standard of only 2,500 pounds per man hour was estimated for this job in contrast with a rate with field crates of 5,000 pounds per hour, with hand methods, and 16,700 pounds per machine hour with a mechanical dump.

(2) *Quality sort.* The one major difference between regions in apparent labor requirement for accomplishing the same task is found in the sorting operation. Whereas the labor standard for sorting developed in the California study is approximately 600 pounds per sorter hour when operating under average conditions with respect to berry quality, it was found, from observation of the sorting operation in several processing plants and from interviews with plant managers, that processing plants of other areas used much more sorting labor, averaging one sorter hour for every 300 pounds of raw product. Uniformity in development of regional standards for this job was attempted. This involved recognizing that the average sorter labor output in California plants during the periods studied was 10 per cent below the standard developed. Therefore, the average of actual sorting labor output of areas other than California was inflated to develop a standard which held the same ratio to the average as in California.

(3) *Casing.* The casing standards developed in California relate to the immediate placement of filled cartons into fiberboard cases. In many areas of the country, however, the cartons are placed on trays for freezing before they are cased. It is claimed that this improves berry quality due to faster freezing. Costs, however, are increased approximately one-tenth cent per pound due to the extra labor of placing the cartons on trays, putting the trays into and removing them from the freezer, and dumping the trays or otherwise delivering the cartons to the casing workers. This variation adds a comparatively small amount to processing costs and would have little or no effect on comparative costs between regions if uniformly practiced, so cost estimation in this study is based on casing prior to freezing—the method about which the most information is available. Uniform practice in the long run seems to be a reasonable assumption on the basis that

the more costly procedure would prevail only if processors were reimbursed for the extra cost and that it would be abandoned where now used if the additional return were not realized.

(4) *Superintendence and miscellaneous labor.* The superintendence and miscellaneous labor cost relationships derived with respect to California wage rates were adjusted to other regions on the basis of the ratio of the base wage rate of each region to the California base wage rate. For example, if the base wage rate of region X were three fourths as great as the California base wage rate, the superintendence and miscellaneous labor cost of region X was estimated at three fourths of the superintendence and miscellaneous labor cost of a comparable California plant.

TABLE 12

REGIONAL BUILDING CONSTRUCTION COST INDICES APPLICABLE TO STRAWBERRY PROCESSING PLANTS, 1958

Region	Cities used as bases of regional building cost indices*	Index†	Regional building cost as a per cent of California building cost
1	Boston, Philadelphia, Pittsburgh, New York	562	113
2	Detroit, Chicago	538	108
3	Philadelphia	562	113
4	St. Louis	546	110
5	St. Louis	546	110
6	Atlanta	458	92
7	New Orleans	477	96
8	Seattle	467	94
9	Seattle	467	94
10	San Francisco	497	100

* These cities were chosen from a list of 20 major U. S. cities for which building cost indices are given in *Engineering News Record* **159** (16), October, 1957, p. 88. The index for the city or cities nearest the major producing area was used.

† Wherever two or more cities appear in the adjacent column, the average of their indices is given.

(5) *Administration.* The cost equation for administrative inputs developed from data obtained in California was applied directly to other areas as there was insufficient information available on which to base an adjustment. However, if administrative salary differences between regions are, in fact, similar to wage differences between regions, this procedure would give excessive costs for all regions except California. On the other hand, the operation of California plants over a longer processing season is likely to result in more efficient use of the administrative and office force than in other regions. These opposite tendencies are presumed to make the per unit administrative and office costs used approximately equal regardless of plant location.

(6) *Building.* Building costs developed specifically for California are adjusted to other areas through use of building cost indices given in table 12. These indices reflect the relationship, in 1957, of building construction costs in major cities in or near each producing region to the building costs in San Francisco. San Francisco in turn is taken as representative of California, for which building costs were esti-

mated. Building cost indices for 1957 are used because the costs in California were estimated for that year. Adjustment of these costs to the 1958 level in order to correspond with the time period of other regional costs would not significantly affect the study of comparative advantage.

Specifications. To facilitate comparison of processing costs by region, certain specifications—several of which have been noted in the previous section—were made. These are:

1. Berry quality is one of the determinants of strawberry processing cost. In the absence of regional information concerning the quality of strawberries received at the processing plant, the assumption is made of uniform quality with respect to region, that is, that the same percentage of the berries must be discarded before packing. Sortouts plus rots averaged approximately 10 per cent in the California plant studies, so this is used as a basis for cost comparison.
2. Worker efficiency is not a function of plant location or local wage rates.
3. In each region, the most efficient processing techniques are used throughout the processing operation.
4. The number of hours a processing plant operates is determined by the region in which it is located. The estimate of annual operating hours for plants in Regions 3 to 7, inclusive, is 150 hours; of plants in Regions 1, 2, 8, and 9, 200 hours; and of plants in Region 10, 1,000 hours.
5. In all but Region 10, the plants typically are organized for multiple-product output—that is, different types of product as contrasted with different *types of strawberry containers.* In such regions, the costs of equipment used jointly in multiple-product output were allocated in proportion to estimated annual use with each product. Region 10 plants generally are specialized to strawberries; therefore the entire amount of plant fixed costs in this region was charged to strawberry processing.
6. Processing costs are based on the assumption that a single type of strawberry container is packed in a given plant, although most strawberry processing plants pack in several types of container. In such operations, slightly different unit costs with a given type of container are obtained as compared with a single-container operation. Relative costs among regions, however, are not appreciably affected by this assumption, and the single-output costs are used.
7. Since the analysis of interregional competition presented in a later section is made on the simplified basis of only two forms of output—a retail package in 10-ounce cartons, packed 24 per case, and a 30-pound tin—adjusted costs are computed only for these two types of container. Adjusted costs with other container types could easily be developed from cost equations of the type summarized in table 10.

Regional Processing Cost Equations

The results of the California plant cost studies were adjusted along lines described above to provide equations for estimating long-run total season costs for each producing region. These were then converted to average cost equations as follows.

With the number of processing hours per season and the rot plus sortout percentage given, equations for total season cost can be converted to express average costs in terms of plant capacity. For instance, California plants are estimated to operate approximately 1,000 hours per year, and sortouts plus rots are taken as 10 per cent. Using these figures, the total cost equations of table 10 applicable to 10-ounce cartons reduce to:

Common costs,

$$TSC = 19{,}631 + 11{,}411.3\,(I)\ ;$$

slicing and sugar mixing,

$$TSC = 475 + 60\,(I)\ ;$$

10-ounce cartons, 24 per case,

$$TSC = 6{,}833 + 2{,}703\,(P).$$

These total season costs are converted to average costs by dividing by total season volume (hours operated times hourly capacity). Thus, the average-cost equations are:

Common costs,

$$AC = 19{,}631/(I) + 11.4113\,;$$

slicing and sugar mixing,

$$AC = 0.475/(I) + 0.060\,;$$

10-ounce cartons, 24 per case,

$$AC = 6.833/(P) + 2.703;$$

where AC is the average cost (in dollars) per 1,000 pounds of product.

Since 10 per cent of the strawberries is discarded, 1,000 pounds of input berries are reduced to 900 pounds of output berries. The most common strawberry-sugar ratio is four parts berries to one part sugar. Using this ratio, 225 pounds of sugar are added to 900 pounds of berries, and the original product input becomes 1,125 pounds of finished product. Using this ratio and converting to an output basis, the common-costs equation becomes:

$$AC = 17.4497/(P) + 10.1433\,;$$

and the slicing-and-sugar-mixing equation is

$$AC = 0.4222/(P) + 0.0533.$$

The total average cost of packing strawberries in 10-ounce cartons is the sum of the common costs, slicing and sugar mixing, and 10-ounce cartons—24 per case—average-cost equations. Total average processing costs in California are found for 10-ounce cartons from the following equation,

$$TAC = 24.705/(P) + 12.900,$$

in which TAC represents total average cost in dollars per 1,000 pounds processed.

Through a similar procedure, the average costs of processing strawberries for freezing in the 10-ounce retail pack can be found for each of the major

producing regions, and this also may be done with respect to 30-pound tins. Long-run average cost equations obtained in this way for these two types of container are given in table 13.

From the coefficients of the equations given in table 13, it appears that regional processing costs fall into four groups. Within these groups, the average cost curves are so nearly the same that they may, for practical purposes, be represented by the same curve. These are shown graphically in figures 22 and 23. Region 10 processing costs are shown to be definitely lower than all others throughout the range of plant sizes. This is due to the longer processing season (see fig. 16), and occurs despite the relatively high level of wages in Region 10. Regions 1 and 2 are found to have lower processing costs than all others except Region 10. This is primarily because of their comparatively low wage rate and slightly longer processing season as compared with some of the other regions. Processing costs in Regions 8 and 9 are highest because of a combination of moderately high labor costs and a short processing season.

TABLE 13

EQUATIONS OF LONG-RUN AVERAGE TOTAL COST OF PREPARING STRAWBERRIES FOR FREEZING IN RELATION TO PRODUCING REGION AND TYPE OF CONTAINER, 1958

(Cost of sugar, container, and freezing not included.)

Region	Principal producing state	Total average cost equation*	
		10-ounce carton, 24 per case	30-pound tin, whole strawberries
		dollars per 1,000 pounds packed	
1	New York	TAC = 31.492/(P) + 17.319	TAC = 25.598/(P) + 13.151
2	Michigan	TAC = 31.322/(P) + 17.288	TAC = 25.406/(P) + 13.907
3	Virginia	TAC = 38.580/(P) + 19.110	TAC = 31.543/(P) + 13.951
4	Tennessee	TAC = 38.673/(P) + 19.241	TAC = 31.741/(P) + 14.096
5	Arkansas	TAC = 38.728/(P) + 20.050	TAC = 31.692/(P) + 13.996
6	Florida	TAC = 38.157/(P) + 18.995	TAC = 31.121/(P) + 13.833
7	Louisiana	TAC = 38.284/(P) + 19.031	TAC = 31.247/(P) + 13.869
8	Washington	TAC = 38.826/ P) + 19.566	TAC = 31.617/(P) + 15.144
9	Oregon	TAC = 38.826/(P) + 19.566	TAC = 31.617/(P) + 15.144
10	California	TAC = 24.705/(P) + 12.900	TAC = 19.704/(P) + 11.396

* TAC represents total average cost of preparation for freezing, dollars per 1,000 pounds; P represents packed output rate in 1,000 pounds per hour.

Total Processed Product Cost

With the foregoing materials, the at-processing-plant long-run supply price of frozen strawberries in 10-ounce and 30-pound containers can be calculated by region. This may be done for each region in terms of the regional processing cost equation plus a constant composed of the estimated unit costs of farm production, sugar, container, freezing, and processor selling.

Components of the constant term for regional total average cost are summarized in table 14. The estimates of farm production cost given there are taken from table 9. Regional container costs are based on estimates of leading container suppliers, and sugar costs are based on quotations and estimates of several sugar manufacturers and sugar brokers. The regional

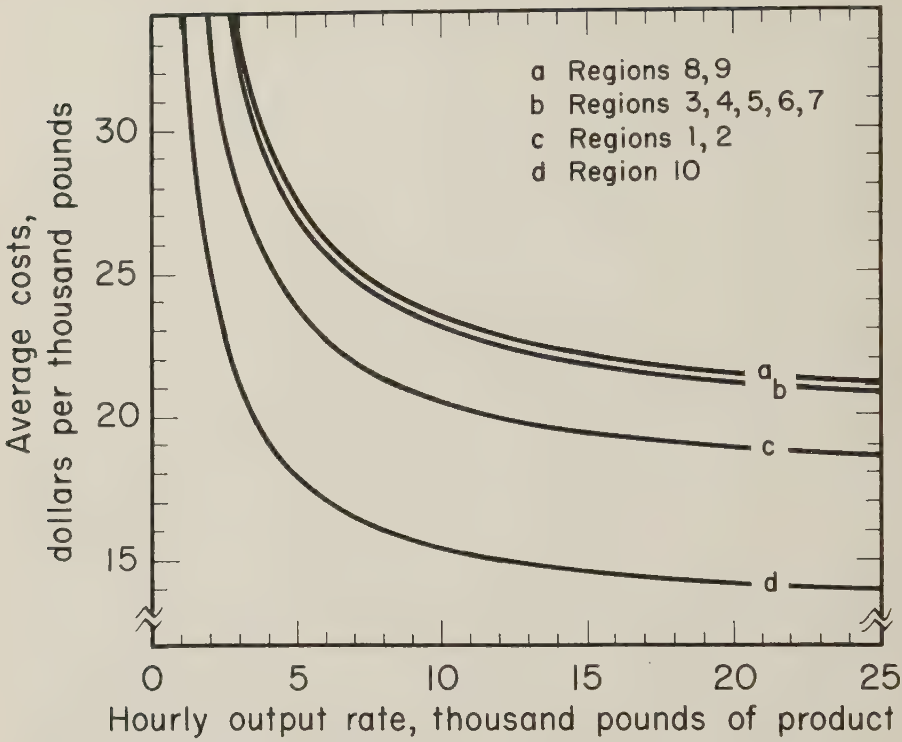

Fig. 22. Comparison of regional average long-run costs in plants packing strawberries in 10-ounce cartons, 24 per case, for freezing—costs based on removal of 10 per cent of berry input from the inspection belt and a 4-to-1 berry-sugar ratio.

unit costs of freezing given in the table are based on quotations by commercial freezing firms and estimates of processing plant managers.

Processor sales expense is difficult to estimate because of the large variation among processors in this expense and the intermingling of sales and other expenditures. For instance, portions of telephone, telegraph, and administrative expenses usually consist of unidentified charges which are actually sales costs. Estimates of sales costs obtained from the records of brokers and processors vary from less than 4 per cent to more than 8 per cent of the processor gross sales. In this study, 6.5 per cent of nonsales expenditures (approximately 6 per cent of gross sales) was used to estimate sales cost at the processor level.

The various components of cost are combined in relation to a single output variable—in this case, the volume of packed output. This requires conversion of raw product unit costs to a packed output basis. Under the previous assumptions of 10 per cent berry removal and 4 to 1 berry-sugar ratio, 1 pound of frozen strawberries—not including sugar—requires 1.1111 pounds of raw product. The frozen product—including sugar—is composed of 80 per cent strawberries and 20 per cent sugar. The total average cost of 1,000 pounds of processed product at the freezing plant is then found from the following expression,

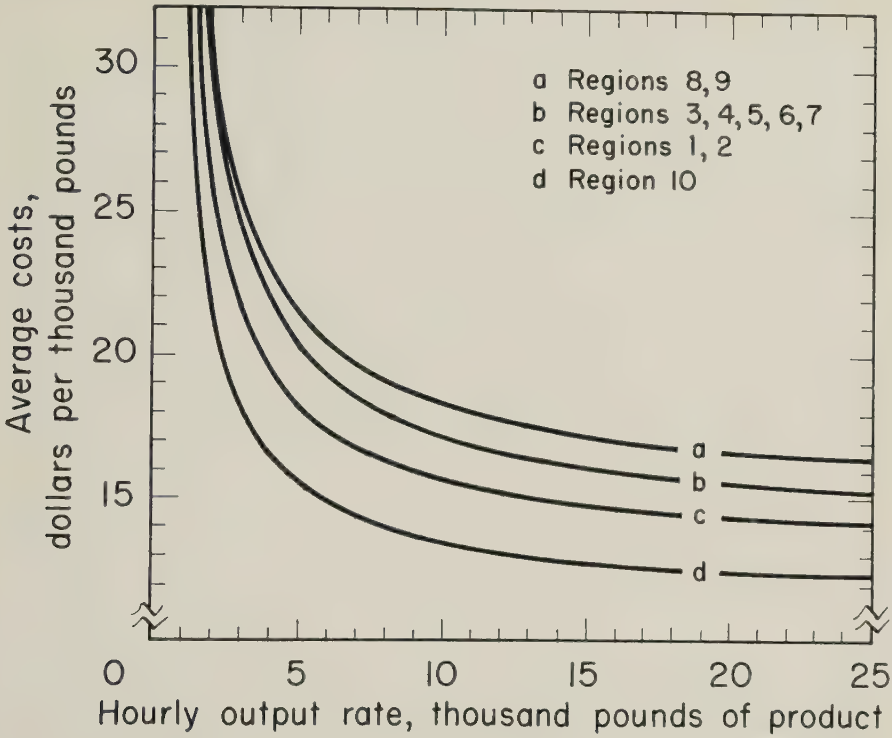

Fig. 23. Comparison of regional average long-run costs in plants packing 30-pound tins of whole strawberries for freezing—costs based on removal of 10 per cent of berry input from the inspection belt and a 4-to-1 berry-sugar ratio.

$$TAC = (0.8)(1.1111)(FP) + (0.2)(SP) + CC + FC + SC + PC \qquad (8)$$

where,

TAC = total average cost of 1,000 pounds of processed product at the freezing plant;
FP = farm production cost per 1,000 pounds of raw product;
SP = sugar price per 1,000 pounds of sugar;
CC = container cost per 1,000 pounds of product (net weight);
FC = freezing charge per 1,000 pounds of product (net weight);
SC = processor selling cost—this is assumed to be 6.5 per cent of the nonsales expenditure;
PC = processing cost per 1,000 pounds of packed product.

The total-average-cost equation for processed product at a freezing plant of each region is found through appropriate substitutions in the above expression. The results, by region, for 10-ounce cartons and 30-pound tins are summarized in table 15.

From the equations in table 15, an estimate of the total average cost to the processor of the finished product at his plant can be computed. These costs are based on single-product operation and would be subject to some economies if the particular product were processed as a part of a larger

operation (for example, see fig. 21). The economies of multi-product operation are available to all regions in essentially similar degree, however, so costs found from these equations are taken as representative of the cost relationships existing between regions. Costs estimated on this basis for 10-ounce cartons and 30-pound tins, when packed in plants of 10,000- and 25,000-pound capacity, are given in table 16. These costs are used as the regional f.o.b. plant prices in the analysis of regional comparative advantage given in a later section.

TABLE 14

ESTIMATED VALUES OF REGIONAL COST COMPONENTS IN THE PRODUCTION AND PROCESSING OF FROZEN STRAWBERRIES, 1958

Region	Farm production cost per pound, raw product	Sugar cost per pound	Container costs: 10-ounce ctns. per case of 24 (all materials)	Container costs: 30-pound tins (each)	Freezing and first month storage: 10-ounce cartons	Freezing and first month storage: 30-pound tins
	cents				*cents per 100 pounds (net weight)*	
1	13.8	9.703	74	38	71.3	63.3
2	11.5	9.378	74	37	87.5	74.7
3	12.6	9.680	75	38	70.0	64.0
4	11.6	9.717	74	37	94.2	84.8
5	16.7	9.676	74	37	94.2	84.8
6	25.1	9.684	76	39	110.0	98.3
7	23.1	9.200	75	38	110.0	98 3
8	9.5	9.737	74	42	85.0	62.0
9	9.7	9.644	74	42	85.0	62.0
10	9.6	9.277	74	42	87.5	80.0

Transportation Costs Between Producing and Consuming Regions

The cost of transporting frozen strawberries from the producing region to the consuming region is the final cost component to be considered. This cost acts directly in the short run to allocate produced supply to consuming regions as well as being a part of total cost in the determination of the location of production in the long run.

As in regard to other components of the production-distribution system, the relationship of theoretical interest is the long-run response, in the supply and costs of transportation services, to differences in the volume of frozen strawberries moved in interregional shipments. Like those pertaining to long-run supply prices for the various components of regional production and processing cost, such relationships would be extremely difficult to develop. It is easy to establish, however, that the volume of movement of frozen strawberries is extremely small in relation to total movement of products in the United States; thus it appears that drastic changes in total volume or in the interregional pattern of shipments of frozen strawberries could occur without an appreciable effect on their transportation costs.

The transportation component of total delivered cost is, therefore, developed on the basis that the current level and structure of rates provide an acceptable approximation of long-run costs for these services. Consider-

able support for this assumption was found in the views of individuals in, or close to, the transportation industry. These suggested that competitive conditions in the trucking industry have resulted in rates very close to long-run costs and that—for the same reason—truck and rail rates are likely to remain essentially in their present relation to each other. Moreover, existing relationships in the transportation rate structure among different regions are considered unlikely to change substantially in the near future. This is attributed to effective resistance of shippers in different regions to changes in the rate structure that would alter the situation as to comparative transportation advantage that now prevails among the various regions.

TABLE 15

TOTAL COST PER POUND OF PRODUCING, PROCESSING, PACKAGING, FREEZING, AND WHOLESALING FROZEN STRAWBERRIES IN RELATION TO PRODUCING REGION AND TYPE OF CONTAINER, 1958

Region	Principal producing state	Total average cost equation*	
		10-ounce carton, 24 per case	30-pound tin, whole strawberries
		dollars per 1,000 pounds	
1	New York	TAC = 33.539/(P) + 229.89	TAC = 27.262/(P) + 185.55
2	Michigan	TAC = 33.358/(P) + 209.09	TAC = 27.057/(P) + 163.88
3	Virginia	TAC = 41.088/(P) + 220.96	TAC = 33.593/(P) + 175.06
4	Tennessee	TAC = 41.187/(P) + 213.51	TAC = 33.804/(P) + 167.63
5	Arkansas	TAC = 41.245/(P) + 262.62	TAC = 33.752/(P) + 215.77
6	Florida	TAC = 40.637/(P) + 344.15	TAC = 33.144/(P) + 297.28
7	Louisiana	TAC = 40.772/(P) + 323.50	TAC = 33.278/(P) + 277.01
8	Washington	TAC = 41.350/(P) + 193.10	TAC = 33.672/(P) + 148.30
9	Oregon	TAC = 41.350/(P) + 194.80	TAC = 33.672/(P) + 150.01
10	California	TAC = 26.311/(P) + 186.23	TAC = 20.985/(P) + 146.20

* In these equations, TAC represents regional total average cost—including the costs of production and assembly of raw product, processing, sugaring, containers, freezing and first month storage, and wholesaling expense; P represents processing plant capacity output rate in 1,000 pounds packed output per hour.

Changes in transportation rates which do not alter the structure of absolute differences in the costs of product movement among the various regions would not alter the situation as to comparative advantage among regions. In general these relationships are, in this study, assumed fixed, although this assumption is modified at a later point in the analysis (see page 584).

While the above opinions have no predictive significance, they at least bolster the assumptions of this study with respect to transportation costs. These assumptions are that, for a substantial future time period, competitive conditions in the transportation industry will act to provide a relatively high degree of stability in the level of transportation rates and in the structure of rates as between regions.

Transportation Rate Estimation

As will appear in a later section, the analyses of interregional competition made in this study require transportation cost data for two periods. Data for 1955 are used in an analysis of the efficiency with which the produced supply of that year was allocated to the various consuming regions,

TABLE 16

TOTAL PROCESSED PRODUCT COST IN THE PREPARATION OF STRAWBERRIES FOR FREEZING IN RELATION TO PRODUCING REGION, TYPE OF CONTAINER, AND PLANT CAPACITY OUTPUT RATE, 1958

Region and type of container	Farm*	Plant: 10,000 pounds per hour capacity	Plant: 25,000 pounds per hour capacity	Sugar†	Container‡	Freezing and first month storage	Total at-plant costs§: 10,000 pounds per hour capacity	Total at-plant costs§: 25,000 pounds per hour capacity
	cents per pound of product							
10-ounce cartons								
1	12.267	2.047	1.858	1.941	4.933	0.713	23.324	23.123
2	10.222	2.042	1.854	1.876	4.933	0.875	21.245	21.044
3	11.200	2.297	2.065	1.936	5.000	0.700	22.507	22.260
4	10.311	2.311	2.079	1.943	4.933	0.942	21.763	21.522
5	14.844	2.392	2.160	1.935	4.933	0.942	26.674	26.427
6	22.311	2.281	2.052	1.937	5.067	1.100	34.821	34.577
7	20.533	2.286	2.056	1.840	5.000	1.100	32.758	32.513
8	8.444	2.345	2.112	1.947	4.933	0.850	19.723	19.474
9	8.622	2.345	2.112	1.929	4.933	0.850	19.893	19.644
10	8.533	1.537	1.389	1.855	4.933	0.875	18.886	18.728
30-pound tins								
1	12.267	1.571	1.417	1.941	1.267	0.633	18.828	18.664
2	10.222	1.564	1.411	1.876	1.233	0.747	16.659	16.496
3	11.200	1.711	1.521	1.936	1.267	0.640	17.843	17.641
4	10.311	1.727	1.537	1.943	1.233	0.848	17.104	16.904
5	14.844	1.717	1.526	1.935	1.233	0.848	21.914	21.711
6	22.311	1.695	1.508	1.937	1.300	0.983	30.061	29.862
7	20.533	1.699	1.512	1.840	1.267	0.983	28.033	27.834
8	8.444	1.831	1.641	1.947	1.400	0.620	15.168	14.964
9	8.622	1.826	1.639	1.929	1.400	0.620	15.338	15.134
10	8.533	1.337	1.218	1.855	1.400	0.800	14.830	14.703

* Ten per cent of raw product assumed removed from sorting belt. Thus, 1.1111 pounds of raw product are required for 1 pound of frozen berries. A 4 + 1 berry-sugar ratio is assumed, so 80 per cent of the product is strawberries (20 per cent sugar). Therefore, to find the cost of strawberries in 1 pound of product, the farm production price is multiplied by 1.1111 and this in turn is multiplied by 0.8.

† Since 20 per cent of the frozen product is assumed to be sugar, the cost of sugar in the product is 0.2 times the price of sugar. Regional sugar prices (per pound), based on estimates of sugar companies and brokers, are: (1) 9.703, (2) 9.378, (3) 9.680, (4) 9.717, (5) 9.676, (6) 9.684, (7) 9.200, (8) 9.737, (9) 9.644, and (10) 9.277.

‡ Estimated container costs are: For 10-ounce cartons per case of 24 (all materials): regions 1, 2, 4, 5, 8, 9, and 10—74 cents; regions 3 and 7—75 cents; and region 6 76 cents. For 30-pound tins (each): regions 2, 4, and 5—37 cents; regions 1, 3, and 7—38 cents; region 6—39 cents; and regions 8, 9, and 10—42 cents.

§ Sum of costs given in this table plus 6.5 per cent of these costs to cover processor selling costs.

while rates for 1957 are developed as an indication of long-run cost for transportation services for frozen strawberries. Since both rail and truck transportation is used by the industry, rates for both must be considered.

The basic transportation rate information used appears in a recent publication of the United States Agricultural Marketing Service (1959*a*), which gives average 1955 and 1957 refrigerated truck and rail-car rates for transporting frozen fruits and vegetables from many producing states into 12 major cities.

Rates for 1955. The truck and rail rates for 1955 referred to above are as published by the Interstate Commerce Commission for truckloads and carlots. The rates for trucks are shown as a scatter diagram in figure 24, where each point represents the average rate per 100 pounds for transportation of frozen fruits and vegetables from a given state to a given city.

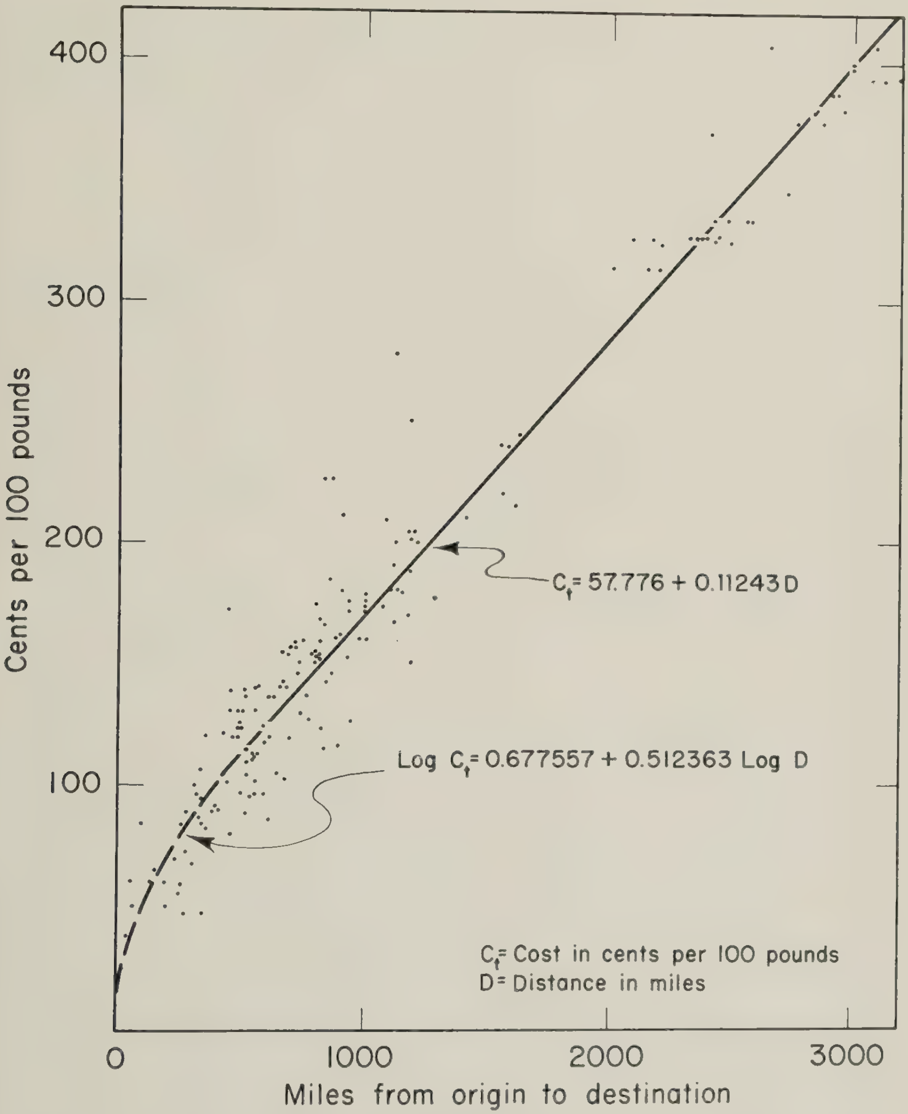

Fig. 24. Truck transportation rates for frozen fruits and vegetables, 1955.
Source: U. S. Agricultural Marketing Service, *Interstate Trucking of Frozen Fruits and Vegetables under Agricultural Exemption,* tables 31–42. Marketing Research Rept. No. 316, March, 1959. Washington, D.C.

The increase in truck transport rates as distance increases appears to be logarithmic in the lower distance range but linear in the higher ranges. A logarithmic regression on observations up to 500 miles was used to calculate costs for distances up to 415 miles. A linear regression on all observations was used to calculate trucking rates for greater distances. These equations—approximately equal at 415 miles—are:

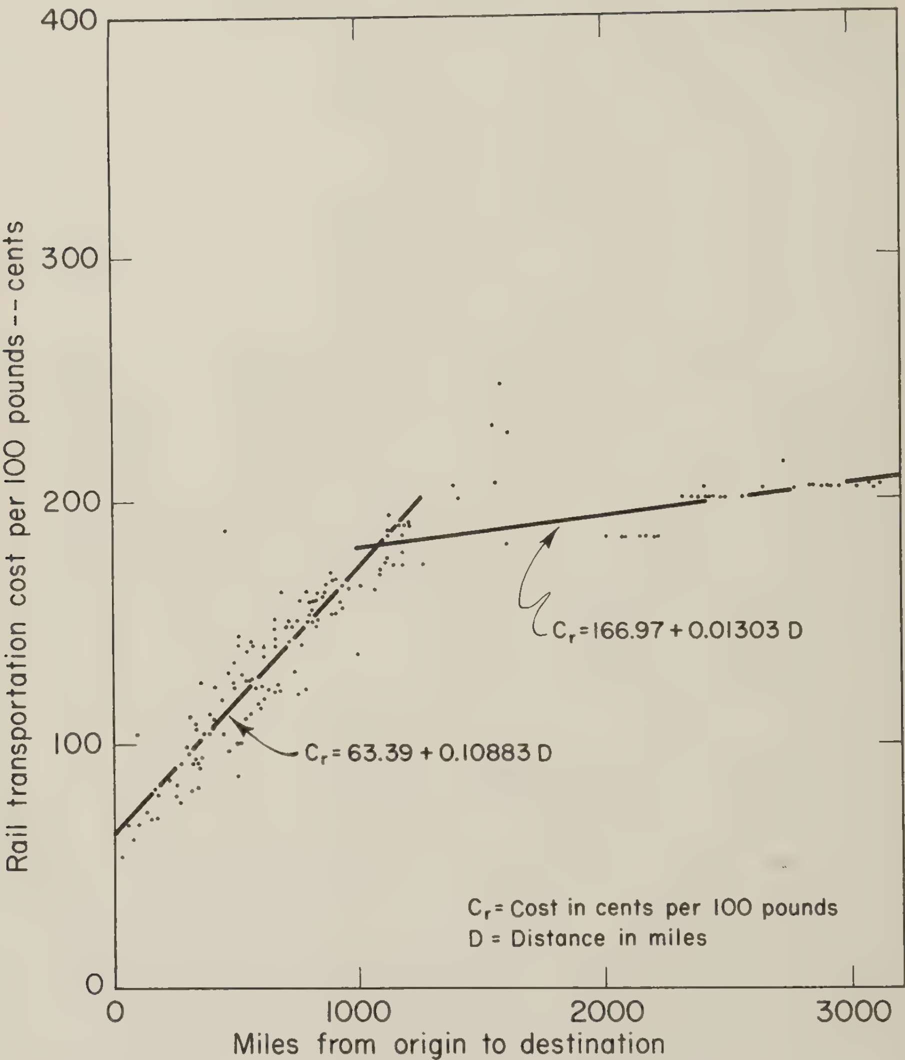

Fig. 25. Rail transportation rates for frozen fruits and vegetables, 1955.

Source: U. S. Agricultural Marketing Service, *Interstate Trucking of Frozen Fruits and Vegetables under Agricultural Exemption*, tables 31–42. Marketing Research Rept. No. 316, March, 1959. Washington, D.C.

$$\text{Log } C_t = 0.677557 + 0.512363 \text{Log } D \qquad (r^2 = 0.45) \qquad (9)$$

$$C_t = 57.776 + 0.112428D \qquad (r^2 = 0.94) \qquad (10)$$

where C_t is the truck transportation cost in cents per 100 pounds and D is the distance in miles.

Rail rates present a different pattern, the short-haul logarithmic relationship observed for truck rates being absent. The data for rail rates indicate a linear relationship for distances up to approximately 1,000 miles,

but the relationship at greater distances is less obvious. Linear regressions over the distance ranges to, and above, 1,000 miles, as shown in figure 25, give the following equations:

Distance less than 1,000 miles,

$$C_r = 63.390745 + 0.108829D \qquad (r^2 = 0.79) \qquad (11)$$

Distance 1,000 miles or more,

$$C_r = 166.970102 + 0.013027D \qquad (r^2 = 0.33) \qquad (12)$$

where C_r is the rail transportation cost in cents per 100 pounds and D is the distance in miles.

While a generalized relationship of rail transportation rates to distance is given in figure 25 and in equations (11) and (12), rail rates from any given point are, in fact, established with respect to zones with the same rate often applying over large areas. This is not readily seen from figure 25, especially for short distances, because the rate information used is for receiving points rather than shipping points and because the points plotted represent rates between many different origin and destination points. When rail rates for a single shipping point are plotted, a definite zonal arrangement, with rates increasing in step form, is apparent. In a later section of this study, both forms are used. The step rate is applied to the analysis of 1955 frozen strawberry distribution, while the more general relationship is—for convenience—used in studies of long-run adjustments.

Comparison of rail and truck distance-rate relationships indicates truck transportation to be lowest in cost for distances not in excess of 1,220 miles. Both truck and rail transport, however, are used frequently to move frozen fruits and vegetables between the same points.

Truck and rail rates as given above are not strictly comparable because greater costs of loading, unloading, and handling are incurred when shipping by rail than by truck. The difference, based on information supplied by local freezing and food storage firms, is estimated at 12 cents per 100 pounds (gross weight). To put rail and truck rates on a comparable basis, this sum is added to the estimated rail rate per 100 pounds.

Rates for 1957. As for 1955, the rail rates for 1957 reported in the study referred to above are Interstate Commerce Commission published carlot rates. The 1957 trucking rates, however, are an average of regulated and nonregulated rates, a reflection of the recent changes in the status of Interstate Commerce Commission regulation of frozen food shipments. These products originally had moved in interstate shipments under regulated rates, but court decisions in 1955 freed them from Interstate Commerce Commission regulation. The use of nonregulated carriers subsequently reduced trucking charges to the extent that, in 1957, the average of regulated and nonregulated trucking rates was 15 per cent below the 1955 average. During this same period, rail rates increased an average of 10.8 per cent.

Frozen fruits and vegetables were returned to a regulated status by Congressional act in 1958, making the trucking rates for 1957 obsolete (Interstate Commerce Commission, 1958). Since the regulated rates later established were not available at the time of this study, it was necessary to adjust those most recently available to a level that would have prevailed

TABLE 17

MILEAGES BETWEEN POINTS IN PRODUCING AND CONSUMING REGIONS

Consuming state	City to which mileage is estimated	Producing region*										
		1	2	3	4	5	6	7	8	9	10	Mexico
		miles										
Maine	Portland	524	1,031	769	1,251	1,561	1,513	1,722	3,144	3,275	3,348	2,837
New Hampshire	Concord	437	944	703	1,166	1,474	1,447	1,656	3,057	3,188	3,261	2,750
Vermont	Burlington	410	917	739	1,139	1,447	1,483	1,655	3,030	3,161	3,234	2,723
Massachusetts	Boston	460	967	664	1,146	1,497	1,408	1,617	3,080	3,211	3,284	2,744
Rhode Island	Providence	456	963	622	1,110	1,456	1,366	1,575	3,076	3,207	3,277	2,702
Connecticut	New Haven	419	883	520	1,002	1,354	1,264	1,473	2,996	3,110	3,175	2,600
New York	Albany	285	792	588	1,014	1,322	1,332	1,504	2,905	3,036	3,109	2,598
New Jersey	Trenton	357	760	386	868	1,231	1,130	1,339	2,873	2,987	3,052	2,466
Pennsylvania	Harrisburg	299	636	331	756	1,107	1,072	1,227	2,749	2,860	2,928	2,354
Ohio	Sandusky	250	260	611	503	793	1,145	1,080	2,373	2,504	2,577	2,065
Indiana	Indianapolis	489	256	732	303	551	1,018	839	2,273	2,331	2,372	1,823
Illinois	Chicago	534	179	878	457	603	1,184	933	2,089	2,226	2,299	1,901
Michigan	Lansing	414	99	766	535	785	1,222	1,084	2,295	2,424	2,497	2,068
Wisconsin	Madison	622	267	966	545	677	1,272	1,011	2,014	2,151	2,319	1,975
Minnesota	Minneapolis	963	608	1,307	853	619	1,582	1,203	1,660	1,797	2,105	1,906
Iowa	Des Moines	870	513	1,199	670	361	1,397	945	1,849	1,884	1,957	1,648
Missouri	Jefferson City	860	546	1,089	430	212	1,151	718	2,100	2,047	2,004	1,511
North Dakota	Jamestown	1,298	943	1,642	1,191	863	1,918	1,482	1,363	1,500	1,843	2,060
South Dakota	Sioux Falls	1,036	732	1,431	951	541	1,671	1,160	1,573	1,710	1,883	1,772
Nebraska	Omaha	1,010	653	1,322	787	360	1,490	979	1,745	1,745	1,818	1,617
Kansas	Wichita	1,201	883	1,433	746	203	1,388	766	1,911	1,835	1,660	1,301

District of Columbia	Washington	404	667	217	699	1,124	961	1,170	2,780	2,894	2,945	2,279
Virginia	Richmond	494	755	107	636	1,169	851	1,107	2,860	2,963	2,961	2,234
West Virginia	Charlestown	435	503	418	419	851	913	998	2,566	2,645	2,675	2,003
North Carolina	Raleigh	633	854	136	562	1,095	694	983	2,917	2,996	2,887	2,110
South Carolina	Columbia	813	878	387	465	1,003	492	791	2,895	2,935	2,735	1,918
Georgia	Macon	992	896	589	349	862	387	589	2,863	2,826	2,571	1,716
Florida	Tampa	1,309	1,274	861	727	1,185	0	736	3,235	3,182	2,826	1,865
Kentucky	Louisville	547	369	694	190	575	914	767	2,386	2,417	2,399	1,769
Tennessee	Nashville	732	559	714	0	543	727	577	2,514	2,477	2,325	1,601
Alabama	Birmingham	932	777	768	218	628	557	401	2,678	2,625	2,340	1,528
Mississippi	Jackson	1,135	911	1,021	403	550	696	173	2,591	2,504	2,130	1,275
Arkansas	Little Rock	1,075	815	1,074	360	280	952	364	2,360	2,303	1,971	1,241
Louisiana	Baton Rouge	1,309	1,084	1,169	577	644	736	0	2,598	2,511	2,137	1,133
Oklahoma	Oklahoma City	1,282	1,000	1,424	710	242	1,289	609	2,034	1,947	1,615	1,139
Texas	Waco	1,500	1,222	1,485	785	464	1,144	443	2,230	2,143	1,750	835
Montana	Lewistown	1,856	1,501	2,200	1,747	1,351	2,476	1,931	821	958	1,327	2,271
Idaho	Boise	2,291	1,934	2,600	2,014	1,575	2,719	2,048	550	463	748	2,155
Wyoming	Casper	1,605	1,215	1,949	1,377	950	2,082	1,502	1,160	1,165	1,268	1,842
Colorado	Denver	1,553	1,198	1,801	1,199	719	1,896	1,211	1,413	1,326	1,364	1,545
New Mexico	Albuquerque	1,800	1,482	1,978	1,264	774	1,765	1,076	1,543	1,456	1,061	1,172
Arizona	Phoenix	2,243	1,925	2,421	1,707	1,217	2,171	1,465	1,577	1,336	715	1,320
Utah	Salt Lake City	1,981	1,624	2,290	1,704	1,221	2,361	1,672	926	839	846	1,779
Nevada	Reno	2,510	2,153	2,819	2,233	1,742	2,799	2,110	778	537	324	2,104
Washington	Seattle	2,623	2,268	2,967	2,514	2,105	3,235	2,598	0	241	963	2,705
Oregon	Salem	2,754	2,397	3,063	2,477	2,038	3,182	2,511	241	0	722	2,618
California	Bakersfield	2,648	2,330	2,826	2,112	1,622	2,613	1,924	1,075	834	213	1,822

* Mileages estimated from the following cities (numbers refer to producing region): (1) Buffalo, New York; (2) Muskegon, Michigan; (3) Norfolk, Virginia; (4) Nashville, Tennessee; (5) Joplin, Missouri; (6) Tampa, Florida; (7) Baton Rouge, Louisiana; (8) Seattle, Washington; (9) Salem, Oregon; (10) Salinas, California; and (Mexico) Irapuato, Guanajuato.

Source: Household Goods Carriers' Bureau, *Mileage Guide No. 4* (Washington, D. C., December 15, 1941).

TABLE 18

ESTIMATED BETWEEN-POINTS TRANSPORTATION RATES FOR FROZEN FRUITS AND VEGETABLES, GROSS WEIGHT BASIS, 1955*

Consuming state	Producing region 1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	117	174	144	212	174	190	196	216	216	216	242
New Hampshire	107	164	137	189	174	196	196	216	216	216	242
Vermont	104	161	141	186	174	196	196	216	216	216	242
Massachusetts	109	166	132	187	174	196	196	216	216	216	242
Rhode Island	109	166	128	148	174	196	196	216	216	216	242
Connecticut	105	157	116	170	174	196	196	216	216	216	242
New York	86	147	124	172	174	196	196	216	216	216	242
New Jersey	97	143	101	155	174	185	196	216	216	216	221
Pennsylvania	88	152	93	143	182	178	196	216	216	216	221
Ohio	81	82	126	114	147	187	179	212	212	212	221
Indiana	113	82	140	89	120	172	152	212	212	212	221
Illinois	118	68	156	109	126	191	163	196	196	196	221
Michigan	104	50	144	118	146	212	180	212	212	212	221
Wisconsin	128	83	166	119	134	212	171	196	196	196	221
Minnesota	166	126	216	154	127	212	193	189	189	196	221
Iowa	156	115	193	133	97	212	164	189	189	189	221
Missouri	154	119	180	106	74	187	139	189	189	189	202
North Dakota	216	164	216	192	155	216	196	181	181	181	221
South Dakota	174	140	216	165	119	216	188	181	181	181	221
Nebraska	171	131	216	146	97	216	168	181	181	181	202
Kansas	193	157	216	142	72	216	144	181	181	181	202
Delaware	105	143	70	152	174	181	196	216	216	216	221
Maryland	99	132	81	141	184	170	194	216	216	216	221
District of Columbia	103	133	75	136	184	166	189	216	216	216	221
Virginia	113	143	52	129	189	153	182	216	216	216	221
West Virginia	107	114	105	105	153	160	170	216	216	216	221
North Carolina	129	154	59	121	181	136	168	216	216	216	221
South Carolina	149	156	101	110	171	113	147	216	216	216	221
Georgia	168	159	124	96	155	101	124	216	216	216	221
Florida	208	212	155	140	191	0	141	216	216	216	221
Kentucky	119	98	136	70	122	161	144	212	212	212	221
Tennessee	140	121	138	0	119	140	123	212	212	212	202
Alabama	163	145	144	75	128	120	102	212	212	212	202
Mississippi	185	160	173	103	120	136	67	212	212	212	202
Arkansas	179	149	179	97	85	165	98	189	189	189	202
Louisiana	216	180	189	123	130	141	0	196	196	189	180
Oklahoma	216	170	216	138	79	216	126	196	196	181	202
Texas	216	212	216	146	110	186	108	196	196	181	180
Montana	216	212	216	212	196	216	196	150	165	181	221
Idaho	216	212	216	212	196	216	196	120	110	142	221
Wyoming	216	194	216	212	196	216	196	181	181	181	221
Colorado	216	192	216	193	139	216	194	181	181	181	202
New Mexico	216	212	216	212	145	216	196	196	196	181	180
Arizona	216	212	216	212	196	216	176	157	157	138	180
Utah	216	212	216	212	196	216	176	162	152	153	202
Nevada	216	212	216	212	196	216	196	145	118	92	202
Washington	216	212	216	212	196	216	196	0	79	164	221
Oregon	216	212	216	212	196	216	196	79	0	139	221
California	216	212	216	212	196	216	176	179	152	74	180

* Gross transportation costs, based on mileages of table 17, obtained as follows:
For distances from zero to 415 miles

$$\text{Log Tr C} = 0.677557 + 0.512363 \text{ Log D},$$

For distances from 416 to 1,220 miles

$$\text{Tr C} = 57.776 + 0.112428\text{D},$$

where Tr C is the transportation cost in cents per 100 pounds, and
D is the between-points distance in miles.

Gross transportation costs for distances of 1,221 or more miles are estimated from zone rates.

under regulation in 1957. It seems reasonable to assume a parallel adjustment in rail and truck rates, and on this basis the regulated trucking rates for 1955 were increased by 10.8 per cent to establish a level that presumably would have prevailed under regulation in 1957.

The 1957 rail transportation rates, on which long-run rail rate estimates are based, follow a step relationship to distance similar to the 1955 rates. This step relationship is likely to apply in future periods. A continuous function of the type represented by equations (11) and (12), however, gives a good representation of the general relation of rate to distance, and it is found in a later section to facilitate portions of the long-run analysis.

Distances

Transportation rates are calculated from a given point of origin to a given point of destination. There are many points of origin in each producing region and many points of destination in each consuming region. To consider every possible point-of-origin, point-of-destination combination would be far beyond the capability—or interest—of this study. The objective here is to determine general relationships, and for this purpose representative transportation distances and resulting cost relationships can be employed.

In most regions, strawberry production is either distributed more or less evenly over a wide area or concentrated in two or more locations. In this study, a point near the geographic center of production of each region was chosen to represent all points of origin of the region. Similarly, a point near the population center of each consuming region was chosen as the regional point of destination. This limits each production region to one point of origin and each consuming region to one point of destination and reduces the possible origin-destinations flows to manageable proportions. This very necessary simplification is another departure from the theoretical framework, but it makes possible a solution—one which closely approximates the result which would be obtained if all possible origins and destinations were explicitly included.

Points chosen to represent each producing region and the consuming center of each consuming region (state) are given in table 17, which also gives the distances between each of these producing and consuming points. Interregional transportation costs are based on these distances between producing and consuming "points."

Interregional Transportation Costs

Unit costs of transportation between producing and consuming regions were computed on the basis of rate and distance data as developed above.

Costs for 1955. The gross transportation rates for 1955, calculated for truck transport from equations (9) and (10) and for rail transport from zone rates, are given for selected transfers between producing and consuming regions in table 18. These rates apply to the gross weight shipped, including product, container, and shipping materials.

To differentiate transportation rates by product and to enable combination of these costs with other costs in this study, it is necessary to convert them to the basis of gross shipping weight of a given net weight of product. Net transportation costs calculated on this basis are given in Appendix

Tables A and B. The conversion is accomplished as follows: A case of 24 10-ounce cartons contains 15 pounds of product. Cartons and shipping materials for one case are estimated at 2.5 pounds, making a gross weight of 17.5 pounds. A 30-pound container (net weight) is estimated at 32 pounds gross weight. With these unit weights, the ratio for converting net weight to gross weight is 1.16667 for 10-ounce cartons and 1.06667 for 30-pound tins.

Costs for 1957. Transportation cost estimation for 1957 was based on the mileages of table 17 and continuous cost-distance relationships. As truck transportation was estimated to be more economical than rail for hauls less than 1,220 miles, equations (9) and (10) were used with distances less than 1,220 miles. Expressions like equations (11) and (12)—but based on 1957 rail-rate data—were used to estimate costs for distances greater than 1,220 miles. For reasons previously indicated, the costs for truck transportation are computed at a level 10.8 per cent above that applying in 1955. With respect to any given interregional shipment, the least-cost mode of transport was used. Estimated costs computed on this basis for selected interregional movements of frozen strawberries at 1957 rates are given in Appendix Tables C and D.

REGIONAL CONSUMPTION ESTIMATES

In the periods preceding and following World War II, there have been marked changes in the pattern of consumption of strawberries. During the 1920's, for example, annual consumption of fresh strawberries was at the relatively high level of 4.2 pounds per capita. Consumption dropped slightly to 3.5 pounds in the 1930's and to 2.1 pounds in the 1940's. In the 1950's per capita consumption of fresh berries has averaged only 1.5 pounds. The decrease in consumption rates during the 1940's can be attributed largely to the disruption of production during the war period, while failure of the fresh market to recover since then can be attributed in large part to rapid growth in the consumption of frozen berries.

Trends in annual per capita consumption of strawberries in the postwar period are shown in figure 26, in which the variable—and slightly decreasing—per capita consumption of fresh berries in the period 1946–1957 is in sharp contrast with the strong upward trend in annual per capita consumption of frozen strawberries. This has been sufficient to offset the decline in per capita consumption of fresh berries and to produce a slight upward trend—averaging 0.05 pound per year—in total per capita consumption. Despite this gain, total per capita consumption was only 3.0 pounds in 1957—less than three fourths as much as the average for the period 1920–1929.

The changes observed in per capita consumption of strawberries suggest the importance of projecting variation in regional demands for strawberries in relation to changes in price and other factors affecting consumer choice. To do so, however, would involve difficulties in no less degree than were noted with respect to development of supply-price relationships in production and distribution. Attempts to approach this problem on the basis of statistical analyses of historical data are severely handicapped by the short time series during which frozen berries have been available in significant quantities, the very strong growth factor during this period, and the diffi-

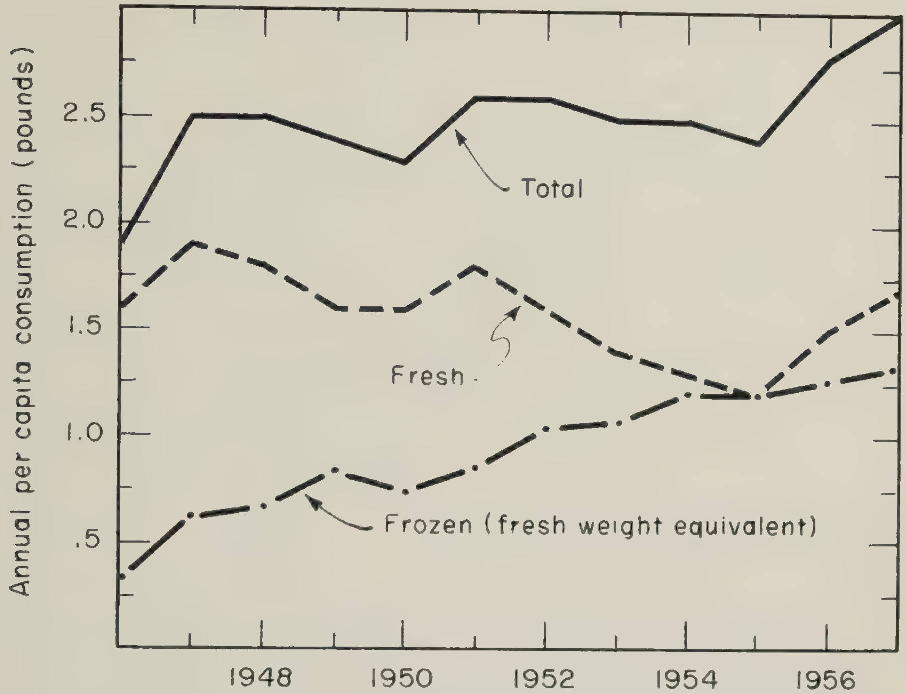

Fig. 26. Per capita consumption of strawberries in the United States—total, fresh, and frozen, 1946–1957.

Source: U. S. Agricultural Marketing Service, *Consumption of Food in the United States, 1909–52*. Agriculture Handbook No. 62, and Supplements for 1955, 1956, and 1958. Washington, D.C.

culty of obtaining adequate regional breakdown. A substitute was therefore sought in terms of estimates of regional consumption in a given year. These estimates are useful in testing the efficiency with which the produced supply of a past period was distributed. And when adjusted for expected future changes in regional population, they contribute to consideration of the efficient location of production of future periods. Lack of predictive quality in such estimates is recognized. However, if consideration is given to alternatives as to the level of future regional consumption, the range in results provides a useful guide as to possible future trends.

Consuming Region Composition

The refinement of results through increased subdivision of the total consuming region is limited by the availability of suitable data regarding each subdivision and by the practical need to restrict computations to a minimum level consistent with obtaining useful results. With respect to data, Bureau of the Census population estimates are available by states, and per capita consumption estimates can be developed for regions comprised of several states. Application of the regional per capita consumption estimate to each of the states included in a given region enables estimation of total consumption for each state. This results in a problem of reasonable size and is within

the limits of available consumption information. Each of the 48 states (Hawaii and Alaska excluded) and the District of Columbia are, therefore, taken as consuming regions.

Regional Consumption Estimation

This section presents estimates of total regional consumption in 1955—a recent year for which the best information is available. Projections also are given of regional consumption in 1970, a year far enough in the future to be of interest with respect to possible long-run adjustments. The consumption figures for 1955 were developed from regional per capita consumption and population estimates for that year, while those for 1970 are based on 1955 per capita consumption and regional population projections for 1970. Two categories of consumption were considered, described here as "retail" and "large size." Retail consumption is defined as including all frozen strawberries packed in containers of 20 ounces net weight or less. The large-size category includes all frozen strawberries packed in containers of more than 20 ounces net weight, and thus includes all institutional and manufacturing packs. Most of the large-size pack is in containers of 30 pounds or more, net weight.

TABLE 19

CONSUMPTION PER HOUSEHOLD MEMBER AND PER CAPITA OF FROZEN STRAWBERRIES FROM RETAIL-SIZE CONTAINERS, 1955

Region	Consumption per household member*	Consumption per capita†
	pounds per year	
New England and Middle Atlantic	1.035	0.96433
East North Central	0.968	0.90190
West North Central	0.899	0.83762
South Atlantic and East South Central	0.545	0.50779
West South Central	0.458	0.42673
Mountain and Pacific	0.500	0.45686
United States	0.768	0.72085

* Source: Preliminary data from a survey conducted by the Market Research Corporation under contract with the Agricultural Marketing Service, U.S.D.A. These data, rounded to two decimals, have since been published in Robert B. Reese, *Family Purchases of Selected Frozen Fruits and Vegetables*, U. S. Department of Agriculture, Marketing Research Report **317** (Washington, 1959), p. 83.

† Regional per capita consumption figures reduced approximately 6.83 per cent to equate estimated consumption and disappearance.

Regional per Capita Consumption

Estimates of per capita consumption in households are available for 1955 with respect to rather broadly defined regions, and these are used as a basis for estimating consumption in the retail category. Similar information is not available, however, in regard to consumption in the large-size category and it was necessary to develop rough approximations of regional consumption by indirect means. The basis for the regional per capita consumption figures used is as follows.

Retail per Capita Consumption. Estimates of regional per capita con-

sumption in the retail category are based on data obtained in a survey of households with respect to the consumption of frozen fruits and vegetables in 1955 (Reese, 1959). The results relating to frozen strawberry consumption, given in table 19, indicate considerable variation among regions in the consumption of frozen strawberries per household member. However, these figures cannot be applied directly to regional population to estimate regional consumption, but must be adjusted to allow for nonhousehold members in the regional population totals.

The first step in adjustment of the regional per capita figure per household member was to determine total per capita consumption for the United States in 1955. This required consideration of alternative estimates of total pack made by the National Association of Frozen Food Processors and the United States Department of Agriculture. These estimates do not differ greatly, and both are presumed to be equally reliable. The Department of Agriculture estimate of a total 1955 pack of 276,179,680 pounds was selected to maintain consistency in source with respect to other estimates used in this study.[8]

To obtain total consumption, the figure for total pack must be decreased by 29,791,000 pounds to allow for the increase in cold storage stocks during 1955; and it must be increased by 13,000,000 pounds to account for Mexican imports in 1955.[9] Using the adjusted total and a 1955 population figure (U. S. Bureau of the Census, 1957) of 164,303,000, annual per capita consumption in all forms was estimated as 1.5787 pounds. Total per capita consumption was divided into the "retail" and "large size" categories on the basis of pack statistics indicating that 45.66 per cent of the strawberries frozen in 1955 was packed in cartons of 20 ounces net weight or less.[10] On this basis, consumption in retail containers in 1955 was estimated as 0.7208 pound per capita.

The estimate developed above on the basis of aggregate industry data differs by a small amount from consumption per household member as given in table 19. The ratio of the two estimates (0.7208/0.768) was used to adjust the regional estimates per household member to regional per capita consumption. The adjusted figures are given in table 19.

Consumption per Capita—Large Size. As defined above, this category includes all frozen strawberries packed in containers of more than 20 ounces net weight. Several studies have been made of this segment of the market, but none has been sufficiently directed toward the regional aspect to permit differentiation of consumption by regions. Consumption estimates by region for this category were therefore made on the basis of a national per capita consumption estimate adjusted by means of indices to indicate regional consumption.

The basic estimate—1955 national per capita consumption in large-size containers—was obtained by applying to total per capita consumption, as computed above, the percentage (54.34) of total product packed in large-

[8] U. S. Agricultural Marketing Service and California State Bureau of Market News, *Marketing California Strawberries, 1957 Season*, prepared by A. M. McDowell and H. E. Tilden (San Francisco: Federal-State Market News Service, 1958), p. 30, table 19.

[9] Page 31, table 22, of reference cited in preceding footnote.

[10] National Association of Frozen Food Packers, *Frozen Food Pack Statistics, Part I—Fruit, 1957* (Washington, D.C.: March 31, 1958).

TABLE 20

ESTIMATING THE REGIONAL PER CAPITA CONSUMPTION OF FROZEN STRAWBERRIES PACKED IN LARGE-SIZE CONTAINERS, 1955

Region	Regional indices of per capita consumption in frozen form		Weighted large-size container use index‡	Per capita consumption (pounds per year)§	Adjusted per capita consumption (pounds per year)‖
	In ice cream*	In preserves†			
(1)	(2)	(3)	(4)	(5)	(6)
New England and Middle Atlantic	102.04	83.19	91.559	0.78547	0.78199
East North Central	114.52	100.50	106.725	0.91558	0.91552
West North Central	110.75	100.50	105.051	0.90121	0.89722
South Atlantic	72.38	105.49	90.789	0.77886	0.77541
East South Central and West South Central	53.20	105.49	82.273	0.70581	0.70268
Mountain and Pacific	126.95	142.60	135.651	1.16373	1.15857
United States	100.00	100.00	100.00	0.85788	0.85788

* Computed from basic data in the following sources: Per capita consumption of ice cream obtained from *Household Food Consumption Survey, 1955*, U. S. Department of Agriculture, table 6 (all urbanizations); percentages of strawberries frozen before use in ice cream taken from U. S. Agricultural Marketing Service, *Distribution of Cold Pack Fruits and Berries to Bulk Users, 1953*, USDA Release of March 15, 1955 (Washington, 1955).

† Computed from basic data given in: *Household Food Consumption Survey, 1955*, U. S. Department of Agriculture, table 12 (all urbanizations).

‡ Weighted average of ice cream and preserves indices (computed as: column 2 times 0.444, plus column 3 times 0.556). The preserves weighting of 0.556 is based on reported use by preserves manufacturers of 55.6 per cent of the frozen strawberries packed in large-size containers in 1953 (see reference in preceding footnote, table 3, p. 4). The ice cream per capita consumption index is considered representative of all other usage of strawberries packed in large-size containers.

§ Obtained by application of weighted "large-size container" use index to United States per capita consumption of frozen strawberries packed in large-size containers.

‖ Regional per capita consumption decreased 0.44314 per cent to equate calculated consumption and calculated disappearance for 1955.

size containers in 1955.[11] This yields an estimate of 0.85788 pound per capita in the large-size category.

Regional differentiation with respect to the national average was developed along lines presented in table 20. Column 1 of this table defines six broad regions. Column 2 gives an index of regional consumption of frozen strawberries in the manufacture of ice cream. The index represents per capita consumption in each region as a percentage of the national average. The estimate of national average consumption in the manufacture of ice cream and ice milk was obtained from the United States Department of Agriculture food consumption survey of 1955.[12] Its distribution by regions was based on the findings of an earlier study which reports the use of frozen fruits and berries in the ice cream industry.[13] Similarly, an index of regional

[11] Based on pack statistics given in reference above, p. 20.

[12] U. S. Agricultural Marketing Service and Agricultural Research Service, *Food Consumption of Households in the United States*, U. S. Department of Agriculture Report No. 1 (Washington, 1956), p. 36, table 6 (all urbanizations).

[13] U. S. Agricultural Marketing Service, *Distribution of Cold Pack Fruits and Berries to Bulk Users, 1953*, USDA Release of March 15, 1955 (Washington, 1955). This study estimates *frozen* as a percentage of *all forms* of fruits and berries used in ice cream to range from 48 per cent in the South Atlantic states to 80 per cent in the western states. Another study, *Food Consumption of Households in the United States* (footnote above) gives ice cream consumption by region. These consumption estimates are converted to an index of frozen strawberry use in ice cream as follows: (1) Strawberry ice cream is assumed to be the same proportion of total ice cream consumption in all regions; (2) regional total ice cream consumption figures are adjusted on the basis of the percentage of *frozen* fruits and berries used in ice cream as given in the reference above; and (3) the results

TABLE 21

TOTAL POPULATION ESTIMATES BY STATE: 1955 AND 1970*

State	1955	1970†	State	1955	1970†
	thousands			*thousands*	
Maine	906	1,012	West Virginia	1,984	2,134.5
New Hampshire	553	647	North Carolina	4,344	5,148
Vermont	370	398.5	South Carolina	2,308	2,733.5
Massachusetts	4,773	5,500.5	Georgia	3,662	4,228.5
Rhode Island	817	924.5	Florida	3,580	5,411
Connecticut	2,200	2,787	Kentucky	3,011	3,124.5
New York	16,021	19,399.5	Tennessee	3,414	3,978
New Jersey	5,324	6,679.5	Alabama	3,110	3,401
Pennsylvania	10,898	12,384	Mississippi	2,133	2,179.5
Ohio	8,945	11,533	Arkansas	1,802	1,634.5
Indiana	4,329	5,528	Louisiana	2,934	3,639
Illinois	9,301	11,097.5	Oklahoma	2,210	2,083
Michigan	7,326	9,921	Texas	8,748	11,278.5
Wisconsin	3,702	4,468	Montana	629	739
Minnesota	3,190	3,765.5	Idaho	612	749
Iowa	2,671	2,911	Wyoming	312	387
Missouri	4,201	4,756.5	Colorado	1,574	2,049
North Dakota	643	662.5	New Mexico	793	1,114.5
South Dakota	683	737.5	Arizona	1,007	1,614
Nebraska	1,394	1,505.5	Utah	797	1,098
Kansas	2,060	2,353	Nevada	235	385
Delaware	390	545	Washington	2,607	3,569
Maryland	2,744	3,802	Oregon	1,685	2,409
District of Columbia	857	1,058.5	California	12,961	19,679
Virginia	3,579	4,455.5			
			Total	164,329	203,600.5

* Source of estimates: U. S. Bureau of the Census, *Current Population Report*, Series P-25, No. **160** (Washington, 1957).

† Average of Series 2 and 3.

consumption of strawberries in the preserve industry was developed.[14] This index is given in column 3 of table 20. Column 4 of table 20 gives a weighted index for large-size container use by regions. These figures are obtained by applying a weight of 0.444 to the regional index of use in ice cream manufacture—assumed to reflect the proportional consumption of large-size pack in all uses except preserves—and a weight of 0.556 to the regional index of use in the manufacture of preserves (U. S. Agricultural Marketing Service, 1955). The resulting weighted regional indices, applied to the national average consumption per capita, give the estimates of regional per capita consumption shown in column 5 of table 20. The final column of the table adjusts the regional per capita consumption figures of column 5 downward

of (2) which represent regional relationships of per capita consumption of ice cream made from frozen fruits and berries are then converted to index numbers representing regional consumption as a percentage of average United States consumption in this category. On the basis of the assumption in (1), this index is then taken to represent the regional distribution of frozen strawberry use in ice cream.

[14] Per capita consumption in this category—defined in terms of "jams, preserves, fruit butters, etc."—is available by regions, based on a food consumption survey of 1955. See U. S. Agricultural Marketing Service and Agricultural Research Service, *Food Consumption of Households in the United States*, U. S. Department of Agriculture Report No. 1 (Washington, 1956), p. 97, table 12.

TABLE 22

ESTIMATED STRAWBERRY CONSUMPTION BY STATE: 1955 AND 1970

State	1955		1970	
	Retail-size containers*	Large containers†	Retail-size containers*	Large containers†
	pounds per year			
Maine	873,683	708,481	975,902	791,372
New Hampshire	533,274	432,439	623,932	505,946
Vermont	356,802	289,336	384,286	311,622
Massachusetts	4,602,747	3,732,428	5,304,297	4,301,324
Rhode Island	787,858	638,884	891,523	722,948
Connecticut	2,131,526	1,720,373	2,687,588	2,179,400
New York	15,449,532	12,528,228	18,707,520	15,170,174
New Jersey	5,134,093	4,163,304	6,441,242	5,223,288
Pennsylvania	10,509,269	8,522,104	11,942,263	9,684,138
Ohio	8,067,538	8,153,527	10,401,668	10,512,535
Indiana	3,904,346	3,945,961	4,985,730	5,038,871
Illinois	8,388,617	8,478,027	10,008,888	10,115,569
Michigan	6,607,354	6,677,780	8,947,797	9,043,168
Wisconsin	3,338,851	3,774,439	4,029,711	4,072,662
Minnesota	2,671,995	2,862,133	3,154,043	3,378,484
Iowa	2,237,273	2,396,476	2,438,300	2,611,809
Missouri	3,518,825	3,769,223	3,984,121	4,267,629
North Dakota	538,587	576,913	554,921	594,409
South Dakota	572,092	612,802	617,742	661,700
Nebraska	1,167,637	1,250,725	1,261,031	1,350,765
Kansas	1,725,489	1,848,274	1,970,911	2,111,160
Delaware	198,037	302,410	276,744	422,599
Maryland	1,393,368	2,127,729	1,930,607	2,948,114
District of Columbia	435,174	664,528	537,493	820,773
Virginia	1,817,371	2,775,198	2,262,446	3,454,846
West Virginia	1,007,450	1,538,416	1,083,872	1,655,116
North Carolina	2,205,828	3,368,387	2,614,089	3,991,818
South Carolina	1,171,973	1,789,650	1,388,037	2,119,587
Georgia	1,859,517	2,839,557	2,147,179	3,278,827
Florida	1,817,878	2,775,973	2,747,637	4,195,752
Kentucky	1,528,948	2,115,763	1,586,581	2,195,517
Tennessee	1,733,586	2,398,943	2,019,978	2,795,253
Alabama	1,579,218	2,185,328	1,726,985	2,389,808
Mississippi	1,083,110	1,498,812	1,106,722	1,531,487
Arkansas	768,963	1,266,226	697,486	1,148,527
Louisiana	1,252,019	2,061,657	1,552,862	2,557,045
Oklahoma	943,068	1,552,918	888,874	1,463,678
Texas	3,733,014	6,147,027	4,812,848	7,925,153
Montana	293,026	728,740	337,619	856,183
Idaho	285,106	709,044	342,188	867,768
Wyoming	145,348	361,474	176,805	448,366
Colorado	720,685	1,792,307	936,106	2,373,908
New Mexico	369,427	918,745	509,170	1,291,225
Arizona	469,121	1,166,679	737,372	1,869,931
Utah	371,290	923,380	501,632	1,272,109
Nevada	109,477	272,264	175,891	446,049
Washington	1,214,497	3,020,390	1,630,533	4,134,934
Oregon	784,974	1,952,189	1,100,575	2,790,993
California	6,038,010	15,016,216	8,990,546	22,799,484

* Includes all containers of 20 ounces or less, net weight.
† Includes all containers of more than 20 ounces, net weight.

by 0.44314 per cent to equate calculated consumption and calculated disappearance.

Population

State population estimates are taken from the U. S. Bureau of the Census (1957) estimates, and the single estimate given is used for 1955. Four estimates of 1970 population are given in this series, based on different assumptions with respect to birth rate, death rate, and migration. In this study, the upper and lower extremes are avoided, and an average of the remaining two estimates is used. These population estimates are given in table 21 for the years 1955 and 1970.

Regional Consumption

As discussed in previous sections, per capita consumption calculations are based on 1955 estimates of production and population and are adjusted to equate calculated consumption and disappearance for that year. Regional per capita consumption is calculated for broad regions, and state consumption is based on state population and per capita consumption of the region in which that state is located. Consumption in 1970 is estimated, using these 1955 per capita consumption estimates and the 1970 population estimate described above. Table 22 gives estimated state consumption of strawberries from retail and large-size containers in the years 1955 and 1970.

LOCATION OF FROZEN STRAWBERRY PRODUCTION

The remainder of this report is devoted to an analysis of the location of frozen strawberry production as determined by the regional cost and consumption pattern indicated in the preceding sections.

A preliminary view of this problem is given by a brief study of the cost relationships developed thus far. This is done in table 23, which demonstrates the ability of the region of largest output (Region 10, California) to compete with frozen strawberries produced locally in each of the remaining producing regions.

The first step in developing these comparisons is to compute, for each producing region, the delivered cost of California frozen strawberries at the consuming center nearest the center of production in each region. Regarding Region 1, for example, this consists of California at-plant total unit cost, plus transportation costs to Albany, New York, the consuming center nearest the producing area of Region 1. This is shown in table 23 to be 21.57 cents per processed pound. The competitive "raw product value" for local producers, then, is estimated by subtracting from the California delivered cost the cost of transportation between local consuming and producing centers and the processing costs applicable to the local region. In the above example, this involves the deduction of 1.11 cents per pound for transportation and 11.05 cents per pound for processing, leaving 9.41 cents per pound as the competitive "product value" facing local producers on the basis of California production and transfer costs into Region 1. These values for the 10 producing regions are given for both 10-ounce cartons

TABLE 23

IMPUTED VALUE OF LOCAL REGIONAL PRODUCTION, BASED ON DELIVERED COST OF CALIFORNIA FROZEN STRAWBERRIES, 1958

Producing region and type of container	Selected geographic centers: Production	Selected geographic centers: Consumption	Delivered cost of California strawberries*	Local nonfarm costs: Transportation†	Local nonfarm costs: Processing‡	Local imputed values: Of processed product§	Local imputed values: Of raw product‖	Local farm production cost¶
	1	2	3	4	5	6	7	8
			cents per pound					
10-ounce cartons								
1	Buffalo New York	Albany New York	21.57	1.11	11.05	9.41	10.6	13.8
2	Manistee Michigan	Lansing Michigan	21.46	0.65	11.03	9.78	11.0	11.5
3	Norfolk Virginia	Richmond Virginia	21.54	0.67	11.31	9.56	10.8	12.6
4	Nashville Tennessee	Nashville Tennessee	21.44	——**	11.45	9.99	11.2	11.6
5	Joplin Missouri	Little Rock Arkansas	21.38	1.10	11.83	8.45	9.5	16.7
6	Tampa Florida	Tampa Florida	21.52	——	12.51	9.01	10.1	25.1
7	Baton Rouge Louisiana	Baton Rouge Louisiana	21.40	——	12.23	9.17	10.3	23.1
8	Seattle Washington	Seattle Washington	20.88	——	11.03	9.85	11.1	9.5
9	Salem Oregon	Salem Oregon	20.53	——	11.02	9.51	10.7	9.7
10	Salinas California	Bakersfield California	19.69	0.96	10.20	8.53	9.6	9.6
30-pound tins								
1	Buffalo New York	Albany New York	17.29	1.02	6.56	9.71	10.9	13.8
2	Manistee Michigan	Lansing Michigan	17.20	0.59	6.44	10.17	11.4	11.5
3	Norfolk Virginia	Richmond Virginia	17.27	0.62	6.64	10.01	11.3	12.6
4	Nashville Tennessee	Nashville Tennessee	17.17	——	6.79	10.38	11.7	11.6
5	Joplin Missouri	Little Rock Arkansas	17.12	1.01	7.07	9.04	10.2	16.7
6	Tampa Florida	Tampa Florida	17.25	——	7.75	9.50	10.7	25.1
7	Baton Rouge Louisiana	Baton Rouge Louisiana	17.14	——	7.50	9.64	10.8	23.1
8	Seattle Washington	Seattle Washington	16.66	——	6.51	10.15	11.4	9.5
9	Salem Oregon	Salem Oregon	16.34	——	6.51	9.83	11.1	9.7
10	Salinas California	Bakersfield California	15.58	0.88	6.17	8.53	9.6	9.6

* Region 10 total at-plant costs (from table 16) plus transportation costs to selected geographic centers (from Appendix Tables C and D). Plant sizes on which regional at-plant costs are based: Regions 8, 9, 10, 25,000 pounds per hour; Regions 1 to 7, 10,000 pounds per hour.

† From Appendix Tables C and D.

‡ Local at-plant total costs for plant of appropriate size (table 16) less farm production costs (table 9) adjusted for culls removed and sugar added in processing. Adjusted farm production costs = (farm cost per pound) (1.1111) (0.80).

§ Column (3) — column (4) — column (5).

‖ Column (6) / (1.1111) (0.80).

¶ From table 9.

** Dashes indicate no interregional transfer involved and so transportation costs are not applicable.

and 30-pound tins in column 6 of the table, where they are described as "imputed values."

The imputed values for processed product given in table 23 must, however, be adjusted for the amount of culls removed and sugar added in processing in order to make them comparable with local farm production costs. The adjusted values—giving the imputed local values per pound of raw (farm) output—are given in column 7 of the table.

Comparison of the local imputed values of raw product (as related to Region 10 delivered costs) with local farm production costs indicates the capability of local producers in competing with shipments from Region 10. For example, the imputed value of raw product in Region 1 is 10.6 cents per pound as compared with estimated local farm production costs of 13.8 cents per pound. This indicates that Region 1 berries cannot compete on a price basis with frozen berries shipped from Region 10. Similarly, local farm production costs are substantially higher than the imputed value of local raw product in Regions 3, 5, 6, and 7. These regions also appear unable to compete—in the consuming region nearest their producing areas—with inshipments from Region 10. In Regions 2 and 4, local farm production costs are only slightly higher than the imputed values in those regions (relative to Region 10 output), while farm production costs are significantly lower than imputed values in Regions 8 and 9. This means that Region 10 (California) has only a narrow advantage in Regions 2 and 4 and is at a competitive disadvantage in Regions 8 and 9.

By extension of this type of comparison, it could be shown that the competitive positions of Regions 8 and 9 relative to other producing regions are similar to that of Region 10. This means that all three regions are close competitors in the national market. Such comparisons, however, are only suggestive, as they permit consideration of the problem only on the basis of each major producing area, taken singly. An appropriate solution requires that the competitive relationships among all producing regions be considered simultaneously. This type of analysis is given below.

The more general solution makes use of the estimates of production and transfer costs developed in the preceding sections for the 10 strawberry producing regions to estimate total delivered unit cost in any consuming region from any producing region. Use also is made of the estimates of consumption developed for a recent year—1955—for 49 consuming areas as well as projections of consumption in those areas in 1970. Two categories of consumption are considered, "retail," involving product packed in containers of 20 ounces or less net weight, and "large size," consisting of packs in containers exceeding 20 ounces net weight and used primarily in the manufacture of food products.

The 49 consuming regions consist of the 48 mainland states and the District of Columbia. The 10 producing regions are defined in figure 13 but are repeated below for ease of reference. (Mexico, from which some frozen berries are imported, is treated as a producing region. It is introduced on a special basis in the analyses, however, because of lack of production and processing cost data.)

PRODUCING REGION	STATES INCLUDED
1	New York, Pennsylvania, Connecticut, Massachusetts, Maine
2	Michigan, Ohio, Indiana, Wisconsin, Iowa
3	Virginia, North Carolina, Maryland, Delaware, New Jersey
4	Tennessee, Kentucky, Illinois
5	Arkansas, Missouri, Oklahoma, Kansas
6	Florida
7	Louisiana, Texas, Alabama
8	Washington
9	Oregon
10	California

Basic Assumptions and Specifications

Analysis of this broad problem requires certain simplifying assumptions and specifications. These, given below, are not unrealistic as they retain basic regional relationships.

1. The abstract, perfectly competitive market in space, form, and time is assumed throughout.
2. The individual firm and, therefore, the producing region, has maximum net profits as an objective and thus will ship to the market which yields the largest returns after deduction of transportation costs.
3. Supply and consumption areas are treated as points. Supply points are chosen near presently important producing areas. Where two or more important producing areas are located within a producing region, a point midway between these areas is chosen. Consumption points are chosen near the estimated population center of the consuming region.
4. The location of ice cream consumption is assumed to coincide with the location of ice cream manufacture. This is less likely to be true of preserves and similar products. With respect to both categories, however, the analyses of interregional movements are based on the cost of transporting frozen product from producing region to point of consumption.
5. Except when otherwise specified, consumers are considered to be indifferent as to the source of strawberries purchased. This assumes either absence of quality or other inherent characteristic differentials among the products of different regions, or indifference on the part of consumers to existing quality differences.
6. The estimated costs of processing and shipping strawberries in 10-ounce cartons and 30-pound tins are considered to be representative of regional cost relationships for all 20-ounce or less (retail-size) and over 20-ounce (large-size) containers, respectively. These particular container sizes are chosen because they represent the major part of the frozen strawberry pack.

Framework of Analysis

The analysis that follows uses several models, each involving certain additional specifications or conditions that represent plausible possibilities of special interest. The models are designed to demonstrate the impact of regional cost relationships, as determined in this study, on production location and the probable effect of variation in those costs and in other locational determinants.

Two of the models relate to production and distribution of the quantities of frozen strawberries actually consumed in 1955. The remaining models consider future adjustments based on estimated regional consumption in 1970. With regard to both periods, consumption of each region has been estimated as a fixed quantity. Output in each producing region is, however, allowed to vary in all except the first model—1955 distribution. Determination of source of supply for each consuming region then depends on the total unit cost of supplying frozen strawberries to that region. With all except Model I, the regional production-consumption flows are determined so as to minimize the total cost of production, processing, and distribution of the total United States consumption under the conditions specified for each model.

The general characteristics of the models considered are indicated below, followed by more detailed specification and results with respect to the individual models.

A. *Analysis of 1955 production and distribution*

Model I: Regional production and consumption are as observed in 1955. The distribution of produced supply is studied from the standpoint of minimizing total transportation cost for the entire output.

Model II: Regional consumption is as observed in 1955, but the location of its production is allowed to assume a pattern that would minimize the total cost of its production and distribution.

B. *Analyses based on projected regional consumption in 1970*

Model III: Regional consumption is as projected for 1970. The location of production that minimizes the total cost of producing and distributing this supply, based on the structure of costs prevailing in 1958, is determined.

Model IV: In this case, the specifications of Model III are changed only with respect to transportation costs. Several levels of increased transportation cost are considered to indicate the effect of shifts in this cost category on regional production allocations.

Model V: In this model, the assumption that buyers do not discriminate with respect to producing region in the purchase of strawberries is abandoned. The effect of this on the location of production is studied in terms of price differentials paid for the product of a given region.

Model VI: In the above, the techniques of berry production are considered fixed. Model VI is designed to show the effect of a cost-reducing technical advance in a particular region.

Model VII: The analysis to this point is based on the production and transfer cost relationships prevailing in 1957–1958, or on the assumption that any changes from this level would be proportionally the same in all regions. Model VII is designed to show the effect of a differential increase in cost level in an important producing region. This is demonstrated through consideration of several levels of cost increase in Region 10, with costs in the other regions remaining at 1957–1958 levels.

Model VIII: In the preceding models, per capita consumption of frozen strawberries is assumed to remain at the 1955 level, with population growth accounting for all increased consumption in 1970 as compared with 1955. Model VIII is based on a projection to 1970 of the average rate of increase in per capita consumption that occurred in the period 1954–1958. This amounts to an increase in 1970 regional consumption of approximately 25 per cent over that previously estimated.

Model IX: The 1970 regional consumption levels of Model VIII are retained in this model, but regional production expansion—unlimited in previous models—is restricted to 75 per cent of the average production for processing in each region for the period 1953–1957.

TABLE 24
ESTIMATED 1955 FROZEN STRAWBERRY PACK, BY PRODUCING REGION AND CONTAINER CATEGORY

Producing region*	Retail-size containers	Large-size containers
	pounds	
2	577,074	10,149,211
3	545,012	545,012
4	6,104,613	10,448,025
5	430,352	736,545
6	1,426,960	1,426,960
7	1,369,675	1,369,675
8	17,084,729	16,480,554
9	42,012,260	36,339,587
10	44,863,045	54,479,392
Mexican imports	4,023,151	8,976,849
Total	118,436,871	140,951,809

* Region 1 did not produce a significant quantity of frozen strawberries in 1955, and so is omitted. Mexican imports are added, leaving a total of 10 regions.

Source: Total regional production of frozen strawberries is compiled from U. S. Agricultural Marketing Service and California State Bureau of Market News, *Marketing California Strawberries, 1957 Season*, prepared by A. M. McDowell and H. E. Tilden (San Francisco: Federal-State Market News Service, 1958), table 24. The totals are divided into "retail size" and "large size" categories on the basis of pack information supplied by the National Association of Frozen Food Packers, Washington, D.C.

Analysis of 1955 Production and Distribution

Model I—1955 Distribution. The objective in the 1955 distribution model is the determination of optimal interregional flows of predetermined production and consumption quantities. Total regional production of frozen strawberries, adjusted for carryover differential, was determined from U. S. Agricultural Marketing Service (1957) estimates. These regional outputs were then divided into "retail" container and "large-size" container packs on the basis of percentages of each container size packed in each region. The percentages used were determined from state statistics furnished by the National Association of Frozen Food Packers. The statistics were given by state for major producing states and, to preserve anonymity of individual packer output, by groups of states for minor producing states. Estimates for minor regions are, therefore, less precise than for major regions. The estimated total import from Mexico was divided into the two size categories as a residual to balance estimated total production and consumption. Table 24 gives the estimated 1955 pack by container size and region.

Total consumption of frozen strawberries by container category was calculated for each state from estimated per capita consumption and state population data. (The procedure followed in this calculation is explained in an earlier section. Estimated state consumption quantities are given in table 22.) Having the regional production and consumption totals, the transportation cost-minimizing interregional flow is easily determined, using the "transportation model" of linear programming. In this solution, each of the 48 states and the District of Columbia are taken as consuming regions, making a total

Table 25

OPTIMAL DISTRIBUTION PATTERN FOR FROZEN STRAWBERRIES PACKED IN RETAIL-SIZE AND LARGE-SIZE CONTAINERS, 1955

Retail size

Producing region*	Distribution: Consuming region	Distribution: Amount
		pounds
2	Michigan	577,074
3	Virginia	545,012
4	Indiana	1,262,861
	Kentucky	1,528,948
	Tennessee	1,733,586
	Alabama	1,579,218
5	Missouri	430,352
6	Florida	1,426,960
7	Mississippi	117,656
	Louisiana	1,252,019
8	Montana	293,026
	Washington	1,214,479
9	Idaho	285,106
	Utah	371,290
	Oregon	784,974
10	New Mexico	369,427
	Arizona	469,121
	Nevada	109,477
	California	6,038,010
8 or 9	Minnesota	2,671,995
8, 9, or 10	Maine	873,683
	New Hampshire	533,274
	Vermont	356,802
	Massachusetts	4,602,747
	Rhode Island	787,858
	Connecticut	2,121,526
	New York	15,449,532
	New Jersey	5,134,093
	Pennsylvania	10,509,269
	Ohio	8,067,538
	Indiana	2,641,485
	Illinois	8,388,617
	Michigan	6,030,280
	Wisconsin	3,338,851
	Iowa	2,237,273
	Missouri	3,088,473
	North Dakota	538,587
	South Dakota	572,092
	Nebraska	1,167,637
	Kansas	1,725,489
	Delaware	198,037
	Maryland	1,393,368
	District of Columbia	435,174
	Virginia	1,272,359
	West Virginia	1,007,450
	North Carolina	2,205,828
	South Carolina	1,171,973
	Georgia	1,859,517
	Florida	390,918
	Mississippi	675,317
	Arkansas	768,963
	Oklahoma	943,068
	Wyoming	145,348
	Colorado	720,685
Mexico	Texas	3,733,014
	Mississippi	290,137

Large size

Producing region*	Distribution: Consuming region	Distribution: Amount
		pounds
2	Ohio	3,273,461
	Indiana	197,970
	Michigan	6,677,780
3	Virginia	545,012
4	Indiana	3,747,991
	Kentucky	2,115,763
	Tennessee	2,398,943
	Alabama	2,185,326
5	Arkansas	736,545
6	Florida	1,426,960
7	Louisiana	1,369,764
8	Montana	726,740
	Washington	3,020,390
9	Idaho	709,044
	Utah	923,380
	Oregon	1,952,189
10	Oklahoma	1,443,572
	New Mexico	918,475
	Arizona	1,166,679
	Nevada	272,264
	California	15,016,216
8 or 9	Minnesota	2,862,133
8, 9, or 10	Maine	708,481
	New Hampshire	432,439
	Vermont	289,336
	Massachusetts	3,732,428
	Rhode Island	638,884
	Connecticut	1,720,373
	New York	12,528,229
	New Jersey	4,163,304
	Pennsylvania	8,522,105
	Ohio	8,153,527
	Illinois	8,478,027
	Wisconsin	3,374,439
	Iowa	2,396,476
	Missouri	3,769,223
	North Dakota	576,913
	South Dakota	612,802
	Nebraska	1,250,725
	Kansas	1,848,274
	Delaware	302,410
	Maryland	2,127,729
	District of Columbia	664,528
	Virginia	2,230,106
	West Virginia	1,538,416
	North Carolina	3,368,387
	South Carolina	1,789,650
	Georgia	2,839,557
	Florida	1,349,013
	Wyoming	448,366
	Colorado	2,373,908
Mexico	Mississippi	1,498,812
	Arkansas	529,681
	Louisiana	691,963
	Oklahoma	109,346
	Texas	6,147,027

* Region 1 did not produce a significant quantity of frozen strawberries in 1955, and so is omitted. Mexican imports are added, leaving a total of 10 regions.

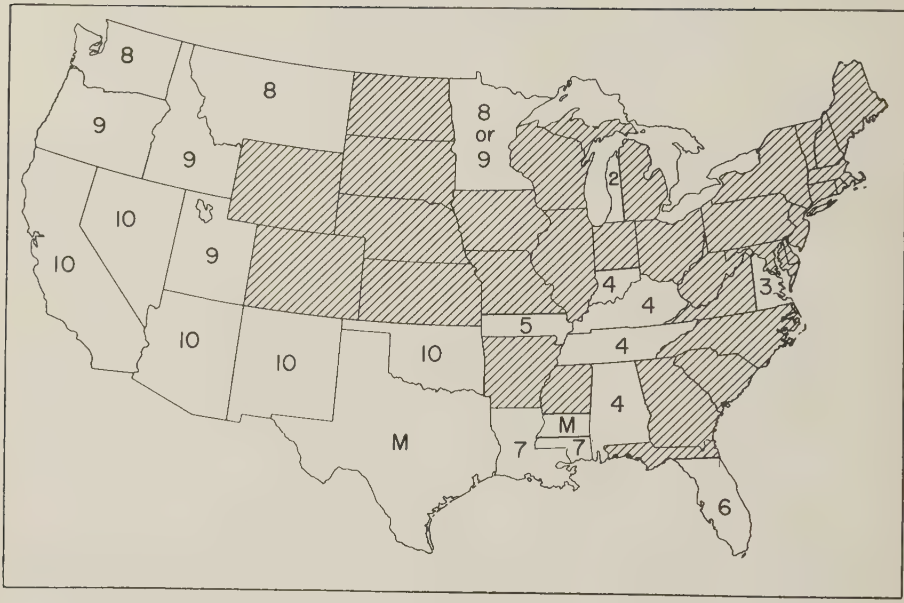

Fig. 27. Optimal distribution pattern for frozen strawberries packed in retail-size containers, 1955.

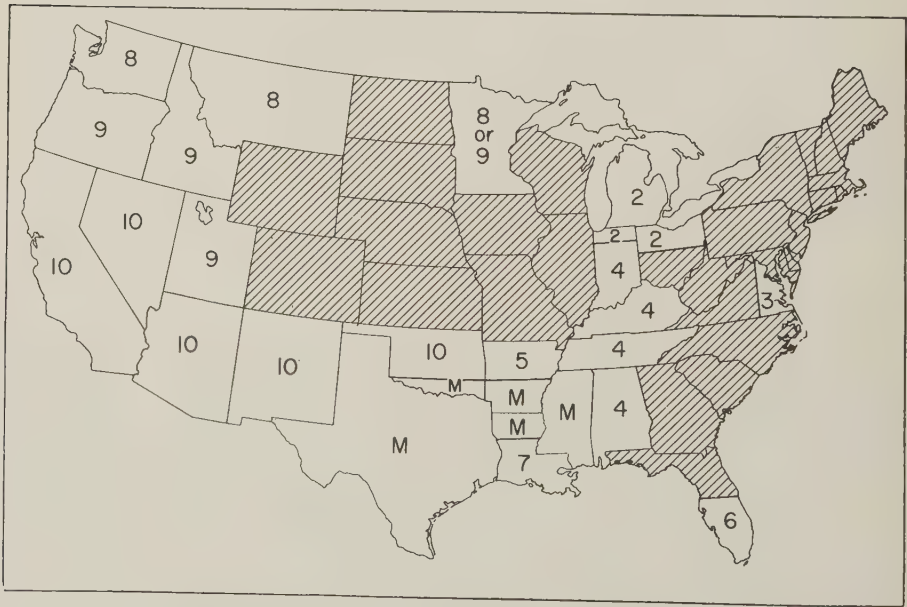

Fig. 28. Optimal distribution pattern for frozen strawberries packed in large-size containers, 1955.

of 49. Of the 10 producing areas, Region 1 did not produce a significant quantity of frozen strawberries in 1955, and so is omitted from the analysis. The remaining nine regions, with the imports from Mexico, make a total of 10 producing regions. A linear programming transportation cost-minimizing solution should, therefore, have 58 interregional movements. The problem is set up as a matrix of 10 columns and 49 rows. The solution must have a number of entries equal to the sum of the rows and columns minus 1—in this case, 49 plus 10 minus 1. For a nonmathematical explanation of the solution procedure, see Snodgrass and French (1957).

Transportation costs given in Appendix Tables A and B are used in this model. This incorporates in the problem the zone structure of rail transportation rates. It means that in many cases identical rates apply from two or more producing regions to a given consuming point. This is particularly true of shipments from the three western regions. There is, therefore, no single optimum solution for this problem.[15]

Table 25 indicates the general nature of the transportation cost-minimizing distribution pattern for 1955. Specific export quantities are shown for the cases where shipments must be made from a specific producing region to minimize total transportation cost. Separate export categories composed of groups of regions are given for the many cases in which alternative producing regions and quantities exported are grouped.[16]

Less than one half of the 1955 optimal movements is identified as originating in one specific region. This would seem seriously to limit the usefulness of the solution of the problem. However, all movements can be identified if the states of Washington, Oregon, and California are considered to be one producing region. Furthermore, it is of interest to know what movements result in an absolute transportation-cost advantage and in what areas some alternative movements are possible without transportation-cost disadvantage.

Figures 27 and 28 show the market areas of the supply regions as given in table 25. In these figures, the specific sources of supply—the producing regions—are identified by number in each consuming state. The shading indicates areas to be supplied by Regions 8, 9, *or* 10. It is interesting to note

[15] This is similar in concept to the "neutral circuits" referred to in Koopmans and Reiter (1951). The "neutral circuits" refer to a situation in which homogeneous products destined for two receiving points pass a common point (such as a cape or narrow passage) en route to their destinations, so that the cargoes could be interchanged without change in total transportation cost.

The strawberry shipments of this study do not necessarily pass a common geographic point but do pass common "transportation cost" zones, resulting in the same effect as noted by Koopmans.

[16] Because of equal transportation costs and joint listing of Regions 8, 9, and 10, the solution does not show a total of 58 interregional movements as required by the "transportation model." And the result is not strictly a "solution," since it does not completely allocate production of Regions 8, 9, and 10 to specific regions. The joint allocation signifies that any one of the large number of possible specific "solutions" which in some manner assigned the strawberries from Regions 8, 9, *and* 10 to the consuming regions now shown as receiving from Regions 8, 9, *or* 10, would result in equal total transportation costs. Any one of the possible specific solutions would require that two of the states receiving from producing Regions 8, 9, or 10 receive from two of those regions or that one consuming region receive from three producing regions. The total movements would then be 58, as required.

the shape of the market areas of the various producing regions. The minor producing regions dispose of their product in immediately adjacent consuming regions. Regions having somewhat greater production than is consumed in the immediate vicinity, supply adjoining areas. The Region 2 and Mexican large-size container supply areas are of the shape expected from theoretical considerations, with the area extending eastward from the producing region, away from major exporting regions. The Region 4 supply area, however, does not appear, on the maps, to have the shape that would be expected. This region would be expected to supply to the east rather than to the north and south. The explanation lies in the transportation rate structure and the difference in location of geographical and population centers of a state. In the rate structure from the western regions, the same transportation rate applies over much of the eastern part of the United States. Short-haul transportation cost from eastern producing areas, on the other hand, increases continuously with distance, and so the minor eastern producing regions tend to supply the nearest consuming "points" regardless of direction. The consuming "point" nearest the producing "point" of Region 4 is in Tennessee, so Region 4 supplies Tennessee. The consuming points following in distance from Region 4 are Kentucky, Alabama, and Indiana, so the balance of Region 4 production goes to these states.

Model II—1955 Total Cost. Model I presents the efficient distribution pattern with the given regional supplies and consumptions of 1955. Model II is designed to determine the production location and export-import pattern for 1955 regional consumption, assuming an adjustment that would have minimized the total cost of its production, processing, and shipping. Comparison of this result and that of Model I provides a measure of the efficiency of the actual pattern of production and distribution in 1955.

Total estimated delivered costs are based on 1955 transportation rates and the 1958 processed product costs of table 16 (p. 558). The nonshipping costs are thus based on 1958 conditions, resulting in an upward bias in total cost and a disproportionately high weighting of nonshipping costs. This, however, only strengthens the conclusions reached as a result of this model.

Total cost determines the location of production in this model. The consumption needs of each region are filled by the producing region which could have produced, processed, and shipped to a given region at the lowest total cost. It is assumed that any processing region could expand production to supply all consuming regions if necessary. Under these assumptions, the solution indicates that, because of its lower producing and processing costs, Region 10 would have produced all of the United States frozen strawberries except the quantities consumed in Washington and Oregon. The Mexican imports, retained at the previously given amounts, would have gone to the states of Texas and Louisiana.

Efficiency of the 1955 Production Pattern. Comparison of the total cost of production, processing, and shipping resulting from the given production locations of Model I and the "efficient" production locations of Model II indicates the efficiency of the production pattern existing in 1955. Mexican production and processing unit costs are assumed to be equal to Region 10 unit costs for the purpose of this comparison. In Model I, the total cost of production, processing, and distribution, with efficient distribution of the

existing supply, would have been about $24,084,000. This same cost calculated under Model II, involving both efficient distribution *and* production (least total cost), would have been approximately $23,455,000. The difference is only about $629,000 (2.6 per cent of the total cost), and in these terms good adjustment is indicated in the frozen strawberry industry with respect to location of production in 1955.

When the difference in production location is given on a pounds-produced basis, however, the industry does not appear to be so well adjusted. In 1955, Region 10 produced nearly 100,000,000 pounds of frozen strawberries—38 per cent of the total United States consumption. If production had been in long-run equilibrium in accordance with Model II, Region 10 would have produced nearly 240,000,000 pounds—92 per cent of the total United States consumption. This considerable difference would seem to indicate a great divergence between actual and long-run equilibrium production locations.

The reason for the apparently conflicting conclusions to be drawn from the comparisons on cost and poundage bases is apparent from the production cost figures of the regions actually producing in 1955. For instance, Regions 8 and 9 were important producers of strawberries for processing in 1955. The estimated total processed product cost in those regions is only slightly higher than that of Region 10. Regions 8, 9, and 10 produced more than 81 per cent of the frozen strawberries consumed in the United States in 1955. The 1955 production given by this model would, therefore, transfer less than 11 per cent of the total United States consumption into Region 10 from eastern regions. Since the total delivered costs of frozen strawberries in eastern markets are only a little higher for berries from eastern than from western producing regions, the per unit cost saving would be very small; thus very large shifts in regional output would yield small savings in total cost. In terms of potential savings, therefore, the industry appears to approximate fairly well an optimum production-distribution pattern.

Analyses Based on Projected Regional Consumption in 1970

The analyses based on projected regional consumption in 1970 indicate the location of production that minimizes total cost of production and distribution under the conditions specified in particular models and using costs for the 1957-1958 period. This implies that costs will not change between 1957-1958 and 1970. The results will, of course, be in error if changes in the relationships among cost components are large enough to change the production allocation for at least one consuming region. Certain types of cost changes, however, could occur without invalidating the analysis. This is true, for example, if the cost relationships remain unchanged; that is, if all costs change by the same percentage. The effect of relative cost-component change is demonstrated in Model IV, where assumptions as to possible future changes in transportation rates—other costs remaining unchanged—are studied with respect to their effect on regional production allocations.

In first approximations to a production-consumption balance in each of the following models, the processing cost used is that applicable to plants of 25,000 pounds per hour capacity rate. If any regions were allocated a very small quantity through this initial calculation, their processing costs were adjusted upward to the level of plants of 10,000 pounds per hour capacity.

The previously determined production-consumption balance was then adjusted to conform with the revised cost structure.

Mexican production and processing costs are not known, and Mexican imports cannot be estimated on a long-run basis. Imports from Mexico were assumed to remain at the 1955 level and were allocated to consuming regions on the basis of minimizing transportation cost. However, an expansion of Mexican output which could be delivered to United States points of entry at prices below at-plant supply prices in the western states would modify the results. The increased volume would compete directly with output of the western states and would tend to reduce allocated production in those regions, and particularly in California.

Model III—1970 Unrestricted Total Cost. In this model, based on estimated 1970 consumption, the only determinant of production location is cost. The region which can produce, process, and ship the product to any consuming area at the lowest total cost will supply all of that market.

Production costs of Regions 8, 9, and 10 are approximately equal. These regions also are about the same distance from the other major consuming markets, so that transportation costs are approximately equal. Although processing costs are not a large part of the total cost where all other costs are nearly equal—as in this case—small differences in processing costs are sufficient to allocate large quantities of production. Region 10 processing costs are lowest of all regions for both container categories, giving this region a total cost advantage over Regions 8 and 9 in production for consumption outside these regions. Region 10 has a transportation cost disadvantage with respect to all regions other than 8 and 9 when shipping to eastern markets.

Because regions which have only slightly higher at-plant processed product cost than Region 10 have equally high transportation costs, and regions of comparatively low transportation cost have high at-plant processed product costs, Region 10 has a total-cost advantage over most of the United States. Therefore, on a least-total-cost basis, Region 10 would supply all of the estimated 1970 consumption of frozen strawberries in the United States with only four exceptions: Washington would be supplied by Region 8; Oregon by Region 9; Tennessee (large-size containers only) by Region 4; and Mexican imports, assumed to continue at the 1955 level, would be absorbed primarily by Texas. The remainder of United States consumption—nearly 300,000,000 pounds and 93 per cent of the total—would be produced in Region 10.

Model IV—1970 Unrestricted Total Cost with Transportation Rate Increase. With transportation cost an important part of delivered cost in consuming markets—especially for West Coast production—the total-cost advantage demonstrated above for Region 10 (California) may be adversely affected by increased transportation cost. Model IV, therefore, considers the effects of increased transportation cost at several levels. The results show that rather large changes in the general level of transportation costs are required to produce substantial changes in the production location pattern.

If, for instance, rates from all regions were increased 10 per cent, the only change would be that Region 2 could then produce in large-size containers

at lowest total cost for the states of Michigan and Illinois. This would cause an increase in Region 2 production from zero to 19,000,000 pounds. If the transportation rates were increased 20 per cent, Region 2 production would increase to nearly 44,000,000 pounds as a result of becoming the region of least total-cost production for Ohio and Indiana large-size containers and for Michigan retail containers. Region 4 would assume production of retail containers for Tennessee. At a transportation rate increase of 30 per cent, Region 2 would increase total production to about 58,000,000 pounds, and at a 40 per cent transportation rate increase, it would expand to more than 73,000,000 pounds. If rates increased 50 per cent, Region 2 would become the least-total-cost producing region—for both retail and large-size containers—for the five comparatively populous states of Illinois, Indiana, Ohio, Michigan, and Wisconsin.

Table 26 shows the estimated 1970 production-consumption balance that would result with a 50 per cent rate increase. Region 4 production is 2,000,000 pounds greater than under 1957 transportation rates. Region 2 would receive the most benefit from the transportation rate increase, since production would increase from zero to over 77,000,000 pounds—24 per cent of total United States consumption. All of the gains of Regions 2 and 4 would represent reductions in Region 10 production, which would decrease from 93 to 67 per cent of United States consumption.

The production allocations determined above on the basis of uniform transportation rate increases among regions would be quite different if relatively larger rate adjustments were to occur in given regions. The competitive advantage of regions experiencing the relatively higher transportation cost would, of course, be reduced.

Model V—1970 Total Cost with Regional Price Differentials. Whether there are inherent quality differences in strawberries produced in different regions, *for which consumers are willing to pay*, could be determined only through a demand analysis which considered strawberries of different origins to be different products. Such an analysis has not been made.

It is generally agreed among industry representatives that consumers do not have a measurable preference for strawberries of specific regional origin. The proponents of differential pricing by region argue that this is because consumers have not been given the opportunity to know the origin of frozen strawberries and thereby to associate quality and region. Quality and brand are considered more likely to be associated. If there were significant differences in quality, it would seem that "best quality" brands would seek the product of "best quality" regions and be willing to pay a premium for that product. If this condition exists in the present market, it is only to a limited extent.

There seems to be less agreement concerning the likelihood of a regional price-quality differential for frozen strawberries packed in large-size containers, especially for that portion used by the preserving industry. The strawberries usually desired for preserving are the Marshall variety of the northwest regions, but there are exceptions. Interviews with freezing and preserving plant managers in many areas of the country indicate that, while most preservers would like to use Marshall berries, they do not agree on the

Table 26

ESTIMATED 1970 PRODUCTION-CONSUMPTION BALANCE FOR FROZEN STRAWBERRIES PACKED IN RETAIL-SIZE AND LARGE-SIZE CONTAINERS, WITH TRANSPORTATION RATES 50 PER CENT HIGHER THAN IN 1957*

Retail size		
Producing region†	Distribution: Consuming region	Distribution: Amount
		pounds
2	Ohio	10,401,668
	Indiana	4,985,730
	Illinois	10,008,888
	Michigan	8,947,797
	Wisconsin	4,029,711
4	Tennessee	2,019,978
8	Montana	337,619
	Washington	1,630,533
9	Oregon	1,100,575
10	Maine	975,902
	New Hampshire	623,932
	Vermont	384,286
	Massachusetts	5,304,297
	Rhode Island	891,523
	Connecticut	2,687,588
	New York	18,707,520
	New Jersey	6,441,242
	Pennsylvania	11,942,263
	Minnesota	3,154,043
	Iowa	2,438,300
	Missouri	3,984,121
	North Dakota	554,921
	South Dakota	617,742
	Nebraska	1,261,031
	Kansas	1,970,911
	Delaware	276,744
	Maryland	1,930,607
	District of Columbia	537,493
	Virginia	2,262,446
	West Virginia	1,083,872
	North Carolina	2,614,089
	South Carolina	1,388,037
	Georgia	2,147,179
	Florida	2,747,637
	Alabama	1,726,985
	Mississippi	1,106,722
	Kentucky	1,586,581
	Arkansas	697,486
	Louisiana	1,552,862
	Oklahoma	888,874
	Texas	789,697
	Idaho	342,188
	Wyoming	176,805
	Colorado	936,106
	New Mexico	509,170
	Arizona	737,372
	Utah	501,632
	Nevada	175,897
	California	8,990,546
Mexico	Texas	4,023,151

Large size		
Producing region†	Distribution: Consuming region	Distribution: Amount
		pounds
2	Ohio	10,512,535
	Indiana	5,038,871
	Illinois	10,115,569
	Michigan	9,043,168
	Wisconsin	4,072,662
4	Tennessee	2,795,253
8	Montana	856,183
	Washington	4,134,934
9	Idaho	867,768
	Oregon	2,790,993
10	Maine	791,372
	New Hampshire	505,946
	Vermont	311,622
	Massachusetts	4,301,324
	Rhode Island	722,948
	Connecticut	2,179,400
	New York	15,170,174
	New Jersey	5,223,266
	Pennsylvania	9,684,138
	Minnesota	3,378,484
	Iowa	2,611,809
	Missouri	4,267,629
	North Dakota	594,409
	South Dakota	661,700
	Nebraska	1,350,765
	Kansas	2,111,160
	Delaware	422,599
	Maryland	2,948,114
	District of Columbia	820,773
	Virginia	3,454,846
	West Virginia	1,655,116
	North Carolina	3,991,818
	South Carolina	2,119,587
	Georgia	3,278,827
	Florida	4,195,752
	Alabama	2,389,808
	Mississippi	1,531,487
	Kentucky	2,195,517
	Arkansas	1,148,527
	Louisiana	1,505,349
	Oklahoma	1,463,678
	Wyoming	448,366
	Colorado	2,373,908
	New Mexico	1,291,225
	Arizona	1,869,931
	Utah	1,272,109
	Nevada	446,049
	California	22,799,484
Mexico	Louisiana	1,051,696
	Texas	7,925,153

* Transportation rates computed on the basis of uniform increase in rate as distance increases.

† Region 1 did not produce a significant quantity of frozen berries in 1955, and so is omitted. Mexican imports are added, leaving a total of 10 regions.

premium that should be paid. Opinions as to the premium that should be given range from zero—despite a stated preference for Marshalls—up to 1 cent per pound.

Although interregional price differentials based on quality characteristics are not now extensively used, there is considerable interest in the effect this could have on the industry. Since the northwest regions are presently recognized as having strawberries of distinctive quality characteristics, the effect of higher prices for berries from Regions 8 (Washington) and 9 (Oregon) is presented.

If we retain Model III with the single exception of valuing Regions 8 and 9 strawberries in both retail- and large-size containers just ¼ cent per pound higher than strawberries from any other region, Region 8 production in large-size containers would increase more than 80,000,000 pounds. The entire increase would come at the expense of Region 10 and would represent a 57 per cent decrease of Region 10 production in large-size containers. The change in retail-size production would be negligible.

If the price differential were ½ cent per pound, Region 8 would increase production in large-size containers nearly 140,000,000 pounds. This would remove Region 2 from the industry and absorb 80 per cent of the production for large-size containers assigned to Region 10 in Model III. Retail-size production would still remain relatively unchanged.

A price differential of nearly ¾ cent per pound is required to allow Region 8 to increase production in retail-size containers. At this price differential, Region 8 would assume over 100,000,000 pounds of the retail-size container production assigned to Region 10 in Model III—causing a decrease of 75 per cent in Region 10 production for retail-size containers. If the price differential were increased to 1 cent per pound, Region 10 would lose nearly 128,000,000 pounds (93 per cent) of the Model III retail-size container production to Region 8.

It is unlikely that all consumers will be willing to pay a price differential for northwestern strawberries. If there is in fact a quality difference, however, certainly some buyers will be willing to pay that differential. The effect of this on the location of strawberry production will depend upon the proportion of the total market those buyers represent. It must also be emphasized that maintenance of the price differential would become increasingly difficult as the volume of premium quality product marketed increased. It can be seen, however, that rather small price differentials can result in large production shifts.

This model can also be used to demonstrate the sensitivity of results obtained to estimated costs employed. If an assumption is made of lower production costs in Regions 8 and 9, rather than higher price for the product, results similar to those of this model will be obtained.

Model VI—1970 Total Cost with Regional Technological Change. The consideration given in this study to the future location of production of strawberries for freezing is based almost exclusively on an assumption of static technology at the level existing in 1958. This is believed to be the best assumption that can be made with respect to technology, since it is based on *known* conditions, and any alternative would of necessity be based on pres-

ently *unknown* conditions. Model VI is presented, however, to show the hazards involved in the assumption of static technology.

A contributing factor in the recent rapid increase in Region 10 strawberry production has been the introduction of new, long-bearing, heavy-yielding varieties which are especially adapted to California growing conditions. Estimation of the reduction in per unit farm production cost brought about by this change is precluded by absence of input-output data for the earlier period. However, if we assume that per unit farm production costs are unchanged from the earlier period—although they probably have decreased because of increased yield—the change in season length has had sufficient

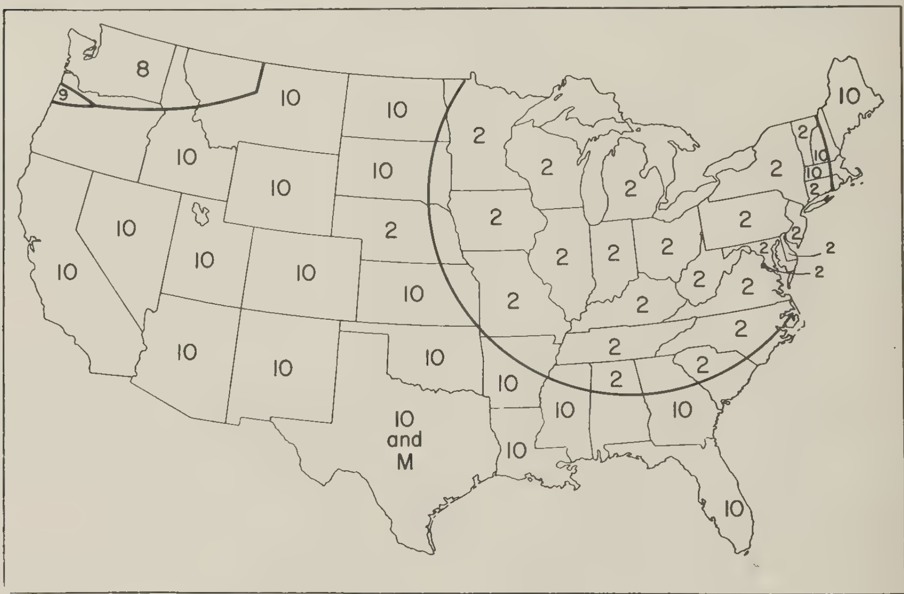

Fig. 29. Optimal distribution pattern for frozen strawberries packed in retail-size containers with assumed Region 2 cost-reducing technological change—Model VI—1970.

impact on processing costs alone to give a total-unit-cost advantage to Region 10. This means that reversion in Region 10 to the 200-hour season applicable in Regions 1, 2, 8, and 9 would result in processing costs in Region 10 sufficiently greater than determined in this study to cause the total-unit-cost advantage now held by Region 10 to shift to Region 8 for all consuming regions except California.

The effects of technical advances in Region 10 could, of course, be modified by future technical developments in other regions. This is illustrated in Model VI by assuming that it becomes possible to produce 50 per cent more strawberries per year on a given bearing acreage of Region 2 and that this increases the length of the producing season 50 per cent. Harvesting costs are assumed to increase 50 per cent (proportionately with yield) but nonharvesting costs to remain as before the technical change. With these assumptions, farm production cost would decrease about 1.44 cents per pound, resulting in a finished product cost decrease of 1.28 cents per pound.

The increased length of processing season—from 200 to 300 hours in Region 2—enables the spread of fixed costs of a given processing plant over more product. This saving would approximate 0.18 cent per pound of product in 30-pound tins and 0.28 cent per pound in 10-ounce cartons.

The f.o.b. processing plant costs applicable to Region 2 under these conditions would be 15.04 and 19.48 cents per pound for strawberries packed in 30-pound tins and 10-ounce cartons, respectively. While these costs are still higher than those of Regions 8 or 10, the decrease of only about 1.5 cents

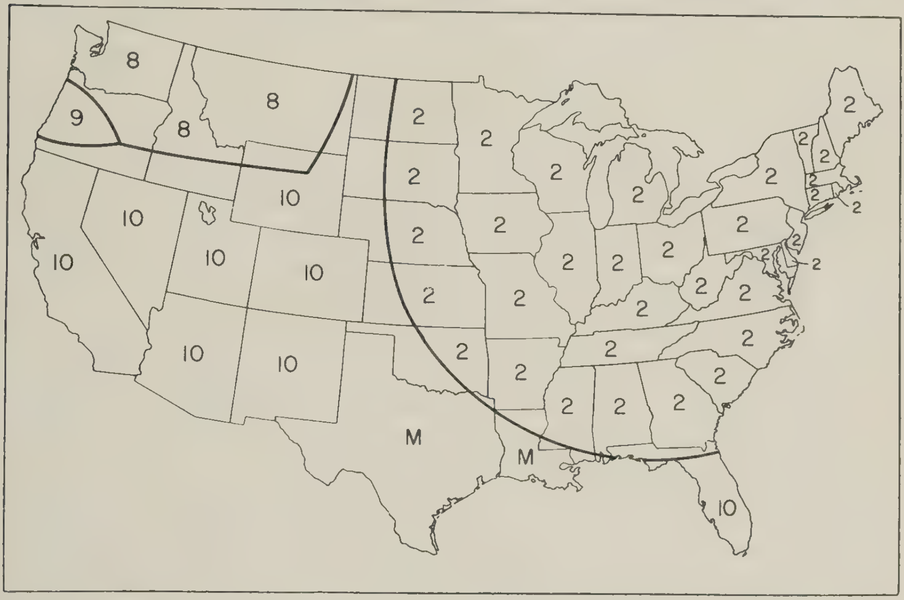

Fig. 30. Optimal distribution pattern for frozen strawberries packed in large-size containers with assumed Region 2 cost-reducing technological change—Model VI—1970.

per pound of frozen product could make Region 2 the most important strawberry producing area in the United States.

Figures 29 and 30 show the theoretical market areas of the regions which could remain in strawberry production under these assumptions. The heavy lines in these figures are the market boundaries for producing regions. Numbers appearing within state boundaries indicate the producing region which the programming solution would assign as the supply source for that state. If a producing region number falls outside the boundary for its market area, it indicates that the consuming "point" falls within the boundary, although a large part of the land area of the state falls outside the boundary.

The boundary of the Region 2 market area is as should be expected, since it extends farther to the east—away from the regions which produce at a lower at-processing-plant cost—than to the west. The boundaries of Regions 8 and 10 are of unusual shape because of the transportation cost relationships used. The sharp break upward in this boundary line is at the point where rail transport becomes the least-cost method for Region 10. The very small increase in rail transportation cost as distance increases, in comparison with

the truck transportation costs of Region 8, forces the boundary abruptly upward. The market-area boundary for Mexican imports cannot be shown because Mexican production and processing costs are unknown. Total transportation cost is minimized by allocating Mexican imports to the states indicated by "M."

The boundaries of Regions 8 and 9 are the same in this model as in Model III, because Region 2 would still be unable to compete in their market areas. Region 2 is shown to supply both retail- and large-size containers to most of the eastern half of the United States, and none of the other eastern regions would produce. Region 10, which under similar conditions and present techniques (Model III) would produce nearly all of the United States strawberries, would decrease production to only about 25 per cent of this volume. Region 2 would increase production to over 225,000,000 pounds—more than 70 per cent of the strawberries consumed in the United States.

Region 10 would still hold a competitive advantage over about half of the area of the United States. Much of this area, however, is sparsely populated. Region 2, being comparatively near major population centers, would hold a comparative advantage in about the same amount of land area as Region 10, but with a population approximately three times as large.

Similar advantages could be gained by any other eastern region if it could develop techniques which reduced total product cost to approximately the level assumed for Region 2 in this example. Because they lack the transportation cost advantage of eastern regions, Regions 8 and 9 would require f.o.b. plant cost reductions to levels below those of Region 10 if they were to capture the eastern markets.

Model VII—Unrestricted Total Cost with an Increase in Region 10 Labor Cost. In the foregoing discussion of future production location, it has been assumed that all production and processing costs will remain at 1957-1958 levels; or that if changes do occur they will be in the same direction, with the same amount of change in all producing regions. A more realistic assumption—based on recent experience—may involve generally rising costs, but at a different rate, in some regions. Unusually rapid growth in population and in industrial and urban development may, for example, create heavier upward pressure on wage rates for processing plant labor in California than in many other states. Wage rates for farm labor in California might be similarly affected if widely used Mexican national labor should become less readily available or if local competitive conditions should require higher wage levels relative to other regions than currently prevail. Model VII, therefore, is designed to show the effect of an increase in production and processing labor cost in California (Region 10) relative to other regions.

Only a very small labor cost increase in Region 10 is required to shift the production advantage for certain consuming areas to other producing regions. If, for example, Region 10 costs are assumed to advance 5 per cent—while all the costs of other producing regions remain constant—this region loses its cost advantage for all except 15 per cent of the United States production in large-size containers. Most of this loss would be a gain by Region 8, although Region 2 would become the low-cost region for 11 per cent of United States consumption in large-size containers. The effect on retail-size

containers would be relatively small, with Region 10 losing about 7 per cent of United States consumption to Regions 2 and 8.

If Region 10 labor costs advanced 10 per cent relative to the other regions, a more drastic change would occur. Region 10 would then lose its advantage for production in retail-size cartons, as well as large-size containers. Region 2 would obtain an advantage in production of 61,000,000 pounds more than in Model III, Region 4 would gain 2,000,000 pounds, and Region 8 would gain 216,000,000 pounds. These gains by other regions would represent a loss on the part of Region 10 of about 88 per cent of its Model III production.

Model VIII—1970 Unrestricted Total Cost with per Capita Consumption Increase. The above models assume per capita consumption of frozen strawberries to remain at the 1955 level. There are, however, indications of recent upward trends in per capita consumption. While the evidence is not adequate for forecasting 1970 consumption rates, it suggests examination of the production allocation that would result with continued growth in per capita consumption. Model VIII, therefore, is based on the assumption that the average growth rate during the period 1954-1958 will continue to 1970.

The trend in total frozen strawberry consumption, 1954-1957, amounted to an average annual increase of about 0.026 pound per person, as estimated from data in U. S. Agricultural Marketing Service (1959*b*). On the assumption of similar annual increases to 1970, per capita frozen strawberry consumption in the United States would increase about 0.390 pound, to 2 pounds per capita, roughly 25 per cent above the 1955 level. If this increase is divided between large-size and retail-size containers in the proportion estimated for 1955, the increase in large-size container consumption would be 0.212 pound per person; retail-size container consumption would increase by 0.178 pound per person.

Since each consuming region in this model would be supplied by the same producing region as in Model III, the changes are in quantity demanded from certain producing regions. The single exception to this generalization occurs in the case of Mexican supplies, where constant Mexican imports are assumed. California would be the source of increased supply for regions receiving some product from Mexico.

With the assumed per capita consumption of this model, total United States frozen strawberry consumption would increase to 402,300,000 pounds from the 321,600,000 pounds of Model III. Of this increase, Washington would supply 1,400,000; Oregon 1,300,000; Tennessee (Region 4), 700,000; and California 77,300,000 pounds. The new total allocated for production in California would be approximately 374,000,000 pounds.

Model IX—1970 Increased per Capita Consumption with Restricted Regional Production. The study of production-consumption flows thus far has assumed that the output of any producing region can be increased to any desired level without increase in farm-supply price. Even under the special circumstances applicable to the frozen strawberry industry, however, very large increases in the output of some regions may be possible only with increased farm-supply price. This would restrain regional output expansion. While there are no available forecasts of these effects, some implications of regional output restriction can be observed by assigning selected limits to

output expansion in any region. This is attempted in a final model in which production-consumption flows are determined on the basis of a projected regional consumption 25 per cent higher than 1955 (as in Model VIII) and an assigned limit on output expansion in any producing region. The production limits chosen, as given in table 27, permit expansion of output in any producing region to a level 75 per cent higher than the regional average production for processing during the period 1953-1957. Imports from Mexico are fixed at 1955 levels, and—for convenience in the problem solution—the retail and large-size Mexican pack is treated as originating in two producing regions.

With the inclusion of Mexico, a total of 12 producing regions is defined, each with a selected maximum output. Since the total of these regional potential outputs exceeds estimated consumption, a "fictitious" consuming region is necessary to absorb the excess potential output. The problem is also modified in this model because the limitation on total regional output requires that the output of each region be allocated between retail- and large-size containers. This aspect was dealt with by defining each geographic consuming region as two regions, one for each type of container. This resulted in a total of 98 geographic consuming regions, plus one fictitious consuming region, and 12 producing regions. Total cost of production, processing, and distribution is to be minimized, subject to the restraints specified.

TABLE 27

REGIONAL PRODUCTION LIMITATIONS, TOTAL OUTPUT OF FROZEN STRAWBERRIES, ASSUMED FOR MODEL IX

Region	Principal producing state	Regional production limits*
		thousand pounds
1	New York	0
2	Michigan	24,160
3	Virginia	4,490
4	Tennessee	36,304
5	Arkansas	8,880
6	Florida	3,668
7	Louisiana	6,958
8	Washington	63,000
9	Oregon	140,382
10	California	212,862
	Mexico†	13,000

* Computed at 1.75 times the average annual regional production reported in U. S. Agricultural Marketing Service and California State Bureau of Market News, *Marketing California Strawberries, 1957 Season*, prepared by A. M. McDowell and H. E. Tilden (San Francisco: Federal-State Market News Service, 1958).

† Approximate amounts imported from Mexico in 1955 and consisting of 4,000,000 pounds in retail-size containers and 9,000,000 pounds in large-size containers.

When total regional output is restricted, the additional problem of its allocation to retail- and large-size containers must be considered. The proportion now packed in different size containers varies among regions; all regions have some output in large-size containers, and in most regions, roughly equal quantities are packed in each category. Since all regions will have some output not suitable for retail pack, but of quality adequate for large-size pack, an additional assumption is made—namely, that at least 25 per cent of the

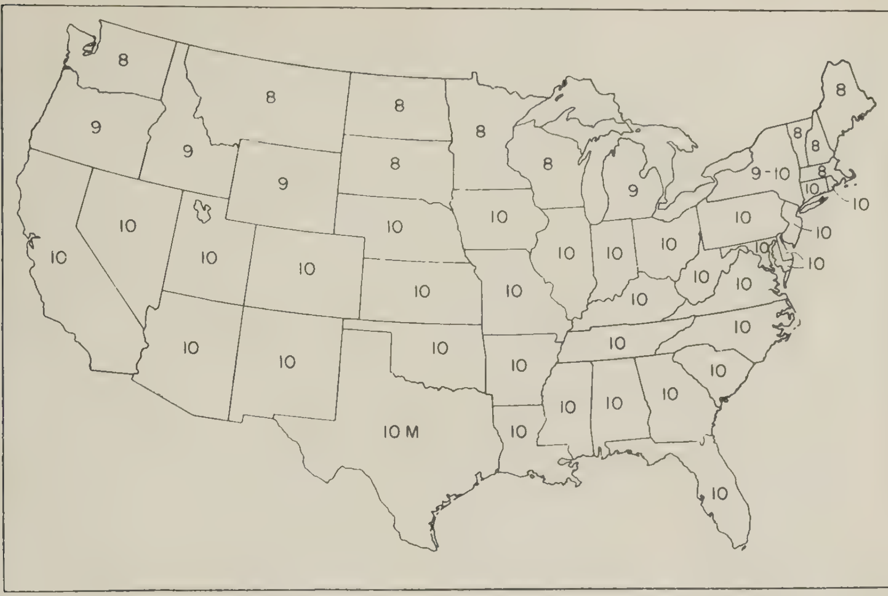

Fig. 31. Production-consumption pattern with increased per capita consumption, 1970, and restricted expansion in regional production—Model IX: retail pack.

Fig. 32. Production-consumption pattern with increased per capita consumption, 1970, and restricted expansion in regional production—Model IX: large-size pack.

TABLE 28

ESTIMATED 1970 PRODUCTION-CONSUMPTION BALANCE FOR FROZEN STRAWBERRIES PACKED IN RETAIL-SIZE AND LARGE-SIZE CONTAINERS, WITH INCREASED PER CAPITA CONSUMPTION AND RESTRICTED REGIONAL PRODUCTION*

Retail size

Producing region†	Distribution: Consuming region	Distribution: Amount
		pounds
8	Maine	1,219,878
	New Hampshire	779,915
	Vermont	480,358
	Massachusetts	6,630,371
	Wisconsin	5,037,139
	Minnesota	3,942,554
	North Dakota	693,651
	South Dakota	772,178
	Montana	422,024
	Washington	2,038,166
9	New York	2,499,425
	Michigan	11,184,746
	Idaho	427,735
	Wyoming	221,006
	Oregon	1,375,719
10	Rhode Island	1,114,404
	Connecticut	3,359,485
	New York	20,884,975
	New Jersey	8,051,552
	Pennsylvania	14,927,829
	Ohio	13,002,085
	Indiana	6,232,162
	Illinois	12,511,110
	Iowa	3,047,875
	Missouri	4,980,151
	Nebraska	1,576,289
	Kansas	2,463,639
	Delaware	345,930
	Maryland	2,413,259
	District of Columbia	671,866
	Virginia	2,828,058
	West Virginia	1,354,840
	North Carolina	3,267,611
	South Carolina	1,735,046
	Georgia	2,683,974
	Florida	3,434,546
	Kentucky	1,983,226
	Tennessee	2,524,972
	Alabama	2,158,731
	Mississippi	1,383,402
	Arkansas	871,858
	Louisiana	1,941,078
	Oklahoma	1,111,092
	Texas	2,016,060
	Colorado	1,170,132
	New Mexico	636,462
	Arizona	921,715
	Utah	627,040
	Nevada	219,864
	California	11,238,182
Mexico	Texas	4,000,000

Large size

Producing region†	Distribution: Consuming region	Distribution: Amount
		pounds
2	Illinois	9,836,040
	Michigan	11,303,960
4	Kentucky	435,578
	Tennessee	3,494,066
8	Maine	989,215
	New Hampshire	632,432
	Vermont	389,528
	Massachusetts	5,376,655
	New York	5,789,549
	Illinois	2,808,421
	Wisconsin	5,090,828
	Minnesota	4,223,105
	North Dakota	743,011
	South Dakota	827,125
	Montana	1,070,229
	Washington	5,168,668
9	Rhode Island	903,685
	Connecticut	2,724,250
	New York	13,173,169
	New Jersey	6,529,110
	Pennsylvania	12,105,172
	Ohio	13,140,669
	Indiana	6,298,589
	Iowa	3,264,761
	Missouri	5,334,536
	Nebraska	1,688,456
	Kansas	2,638,950
	Delaware	528,249
	Maryland	3,685,142
	District of Columbia	1,025,966
	Virginia	4,318,558
	West Virginia	2,068,895
	North Carolina	4,989,772
	South Carolina	2,649,484
	Georgia	4,098,534
	Kentucky	2,308,818
	Alabama	2,129,576
	Oklahoma	1,829,598
	Idaho	1,084,710
	Wyoming	560,458
	Colorado	2,967,385
	Utah	1,590,136
	Oregon	3,488,741
10	Florida	5,244,690
	Alabama	857,684
	Mississippi	1,914,359
	Arkansas	1,435,659
	Louisiana	3,196,306
	Texas	906,441
	New Mexico	1,614,031
	Arizona	2,337,414
	Nevada	557,561
	California	28,499,355
Mexico	Texas	9,000,000

* Based on projected increase to per capita consumption rate 25 per cent higher than 1955; with production expansion in any region limited to a 75 per cent increase over average regional production for processing during the period 1953–1957.

† Region 1 did not produce a significant quantity of frozen strawberries in the period 1953–1957, and so is omitted. Mexican imports are added, leaving a total of 10 regions.

output of any region would be used in large-size containers. Within this limitation, total production, processing, and distribution costs are to be minimized.

A production-consumption pattern based on the above specifications is illustrated in figures 31 and 32. As in Model III, Region 10 (California) is the source of the retail-size pack for most of the United States. Exceptions are the portion of Texas consumption supplied by Mexico and consumption in the northern tier of states (Oregon and Washington, through Maine) supplied by Regions 8 and 9. Under the regional output restrictions of this model, Region 10, however, plays a much less dominant role in the production of the large-size pack. Region 10 would satisfy local consumption needs (California) as well as Nevada and the southern tier of states, plus Oklahoma. Region 8 would supply most of the northern tier of states (excepting Michigan—supplied by Region 2—and a part of the New York requirements—shared with Region 9). The remaining states would be supplied by Region 9, with the exception of Illinois (supplied by Regions 2 and 8) and Tennessee and part of Kentucky (supplied by Region 4).

In terms of total volume of retail pack, table 28 shows that, under the conditions of Model IX, Region 10 would supply roughly 140,000,000 pounds (77 per cent of the total retail pack). The remaining supply would come from Region 8 (22,000,000 pounds and 12 per cent of the total), Region 9 (16,000,000 pounds and 8.7 per cent of the total), and Mexico (4,000,000 pounds and 2.2 per cent). Of the large-size pack, the major portion in this model would be supplied by Region 9 (Oregon), which would produce approximately 107,000,000 pounds (48.5 per cent of the total). Region 10 production would be about 46,500,000 pounds (21.1 per cent) while that of Region 8 would be about 33,100,000 pounds (15.0 per cent). Roughly 21,100,000 pounds (9.6 per cent) would be produced in Region 2. The remainder would be supplied by Region 4 (4,000,000 pounds) and Mexico (9,000,000 pounds).

SUMMARY AND CONCLUSIONS

A basis for studies of interregional competition in regard to a given commodity is found in location and trade theories in economics. These theories conventionally assume the presence, or possibility, of locational advantages in production and distribution. Such advantages and different demands among the various consuming centers determine interregional trade flows. The pattern of trade, in an enterprise economy involving numerous production and consumption centers, develops as a function of product price in the various markets and production and transfer costs in the different producing regions.

At the consumer level, the price of a given product is visualized as a function of such variables as the volume of the product offered, consumer preferences and incomes, and the quantities available and the prices of substitute products. In more simple terms—holding at fixed levels all variables except quantity—price is almost always inversely related to the quantity of product offered.

On the other hand, supplies in producing regions are directly related to price at the producer level, rising as price increases and falling as price decreases. The nature of the regional supply response is determined by the technical characteristics of the production process, and by the amount,

mobility, and prices of local resources such as labor and land. Local resource prices, in turn, are viewed in terms of "opportunity costs" that reflect the regional demand for resource use in the production of alternative goods. Similarly, there is for each region a supply function for processing services and for other services such as transportation, storage, and wholesaling. The sum of these supply schedules for intermediate services and the producer supply schedule provide a schedule of retail price-quantity relationships.

In an isolated market, an equilibrium price results from equating supply and demand functions in that market. In real situations, however, there ordinarily are many supplying areas and many markets all of which are interrelated. The quantity supplied by any producing area and the quantity consumed by any consuming region are conditioned by supply and demand relationships in all other areas.

With regional supply and demand functions given, the marketing area of a supply region is determined through an equilibrium involving transport costs. Assuming competitive market conditions, the market areas defined will satisfy the dual objectives of achieving efficient pricing and minimizing total production and marketing cost. While the nature of these relationships is conveniently demonstrated under the assumption of continuous transport cost functions, these functions are in fact often discontinuous with respect to distance. Supply sources for given consuming regions then may not be uniquely defined.

While the theory is conveniently developed in terms of two regions, practical situations invariably involve many producing and consuming regions. Empiric solution in these complex situations is aided by the use of programming methods; a procedure commonly used involves adaptation of the "transportation model" of linear programming. With this procedure, the solution considers the possibility of trade flows between any producing region and any consuming region, and allocates output to the various regions in the pattern that minimizes the aggregate cost of production and distribution for the various production and consumption regions as a whole.

In applying the above concepts to an empiric solution, consideration of the practical benefits to be derived from inclusion of certain variables, or the limitation of research resources, may suggest simplifications. This was found desirable in the present study. For reasons previously stated, the assumption of perfectly elastic regional supply functions and the estimation of long-run supply price in terms of budget calculations of current production costs was considered a necessary and acceptable simplification for the supply functions visualized in theory. Similarly, it was found desirable to measure regional demand for frozen strawberries in terms of estimated per capita consumption and estimates of regional population totals. Additional simplifications were adopted in defining producing and consuming regions. Whereas, there are virtually innumerable consuming points in the United States, an approximation of the real geographic distribution of consumption was adopted in which each mainland state along with Washington, D.C., was defined as a consuming region. Further, consumption was assumed to be concentrated at a selected population "center" within each region. In like manner, the many producing areas were grouped in 10 major United States regions. Imports from Mexico were considered as the equivalent of an addi-

tional supply region. In each producing region, supplies were assumed to originate at a single, central point. Other simplifications were introduced in regard to transport and distribution costs. Analyses for a future period—1970—involved projections based on estimates of regional population growth and current rates of per capita consumption, and used the current structure of production and transfer costs.

While the empiric model thus developed does not precisely represent the situation in this industry, sufficient realism remains to permit attaining useful approximations. The effect of departures from some of the assumptions used is explored by assigning alternative values to certain strategic variables.

Study of the background of the frozen strawberry industry shows it to have developed with exceptional rapidity since World War II. This growth has been largely concentrated in the states of California, Oregon, and Washington; and, based on production, processing, and shipping costs of 1957-1958 as developed in this study, these states are expected to continue as industry leaders.

Farm-production-cost differences among regions are the largest of the three cost categories considered. The three western regions—California, Oregon, and Washington—were found to have production costs of 1.8 to 2 cents per pound less than any other region.

Processing-cost differences among regions are comparatively small but, when included with other costs, are often sufficient to shift delivered processed product cost advantage among regions. Important determinants of regional processing costs are wage rates and other factor prices, processing techniques employed, and length of processing season. California, due to the longer processing season and in spite of higher wage rates, is able to process strawberries for freezing at a lower cost than any other region. All regions other than California have strawberry freezing seasons of approximately the same length (150 to 200 hours, as compared with 1,000 hours in California) and have relatively little difference in processing costs. Regions 1 and 2 of this study (represented by New York and Michigan) follow California in processing cost advantage. The processing costs of these regions are slightly lower than the next group—Regions 3, 4, 5, 6, and 7 (represented by Virginia, Tennessee, Arkansas, Florida, and Louisiana)—because of their slightly longer processing season. Because of higher wage rates, Regions 8 and 9 (Washington and Oregon) have higher processing costs than other regions of similar length of processing season.

The cost of frozen strawberries at a freezing plant in each region is composed of the costs of farm production and of processing the berries for freezing, plus the costs of sugar, containers, and freezing. California, followed closely by Washington and Oregon, holds an advantage in total at-plant processed (frozen) product cost. Among eastern producing areas, Regions 2 and 4 (Michigan and Tennessee) have lowest total frozen product cost.

The final cost category considered is transportation. Both rail and truck transport are used to move frozen strawberries, and the lowest-cost method was assumed to be utilized in each interregional movement. Truck transport was estimated to be most economical at distances of less than 1,220 miles, and rail transport most economical at greater distances. Rail rates are estab-

lished on a zone basis, resulting in equal transportation costs over large areas from a given shipping region. In the consideration of a past period—1955—appropriate zone rates were utilized. However, for simplification, continuous rail and truck transport cost-distance relationships were utilized in the estimation of future transport costs.

The total cost of frozen strawberries in each consuming region was determined for each producing region from the at-plant processed-product and transportation costs. Within-consuming-region distribution and retailing costs were omitted from the analysis on the assumption that they would be the same regardless of origin of product and would have no influence on a determination of origin of product.

Data on regional consumption and production for 1955—it being the most recent year for which detailed regional consumption estimates were available—were used as the basis of separate determinations of interregional product flows which: (1) represent the distribution pattern for the 1955 regional output that would have minimized the total cost of transporting that produced supply to the consuming regions; and (2) show the location of 1955 production and its distribution to consuming regions that would have resulted in least total cost of production, processing, and transportation of the amounts of frozen strawberries consumed in the various consuming regions in 1955. This analysis indicated that adjustment to a basis of least total cost would have required a considerable change in production location, with California producing 92 per cent of the frozen strawberries. The savings in total cost, however, would have been only 2.6 per cent. There was, therefore, little incentive for further adjustment toward a least-cost production and distribution pattern beyond that already achieved in the frozen strawberry industry in 1955.

Studies of economical adjustments that may be appropriate in the future were based on estimated 1970 regional consumption estimates and 1957–1958 production, processing, and transportation costs. When the location of 1970 production is projected entirely in terms of present indications as to least total cost of production, processing, and transportation (Model III), it appears that California would supply nearly all—93 per cent—of the frozen strawberries produced in the United States. Farm production and transfer costs in Washington and Oregon, however, are nearly equal to those in California, which makes these states close competitors. Only minor changes in cost structure favorable to the northwest would be required to demonstrate an expansion of frozen strawberry output there at the expense of California. Since conditions estimated to prevail in this study can thus be easily disturbed, several alternative formulations were considered.

The effects of uniformly proportional increases in transportation costs from all producing regions were examined (Model IV). A general increase of 10 per cent in transportation costs was shown to result in only minor adjustment in the solution based on current 1957 transportation costs. However, a 50 per cent increase in transportation cost would call for a decrease of about 28 per cent in Region 10 production and increased production in Regions 2 and 4 of 77,000,000 and 5,000,000 pounds, respectively.

The effect of regional product price differentials was considered (Model

IV) by introducing several levels of price advantage for northwest berries—for which some expression of preference was encountered, especially for processed use. If the conditions of least total cost are retained—except for pricing frozen strawberries of Regions 8 and 9 one-fourth cent per pound higher than the product of other regions—the output of Region 8 in large-size containers would increase by 80,000,000 pounds above the level indicated by Model III. An increase of 1 cent per pound would result in a transfer of nearly 128,000,000 pounds of retail-size output from Region 10 to Region 8. Expansion of this magnitude in Region 8 output would, of course, weaken the market for premium-price berries, and this would curtail the possibilities of realizing the production adjustments projected above.

The effects of a technical advance in eastern producing regions comparable with that contributing to the recent rapid expansion in Region 10 output were investigated by assuming a 50 per cent increase in per acre yield and in length of processing plant operating season in Region 2 (Model VI). Such changes would reduce total processed product cost in Region 2 by about 1.5 cents per pound and would provide it with a production-processing-transportation cost advantage over much of the most populous areas of the United States. The resulting increase in Region 2 production would make it the source of 70 per cent of total United States production of frozen strawberries.

A small rise in farm and processing plant labor costs in Region 10 (California) relative to other producing regions was found (Model VII) to reduce greatly the comparative advantage of California in frozen strawberry production. An increase of 5 per cent in Region 10 labor costs—with all other conditions as assumed in Model III—reduced the Region 10 allocation of estimated 1970 production from 93 to only 15 per cent of total United States production in large-size containers. Except for an 11 per cent increase in Region 2 production of large-size containers, reduced output in Region 10 would be offset by increased production in Region 8. A 7 per cent reduction in Region 10 production in retail-size containers would be taken up by Regions 2 and 8. A considerably more drastic change would follow if Region 10 labor costs were to advance by 10 per cent relative to costs in other regions. A loss of about 88 per cent of the output allocated in Model III would be experienced by Region 10, while an increase of 58,000,000 pounds would occur in Region 2, and there would be increases of 2,000,000 and 220,000,000 pounds in the output of Regions 4 and 8, respectively.

When Model III is adjusted to the basis of 1970 per capita consumption, reflecting continuation of the average rate of growth prevailing during the period 1954–1958, estimated per capita consumption increases from the 1955 level of 1.58 pounds to 2 pounds in 1970. Total United States consumption then would be approximately 402,000,000 pounds as compared with the 322,000,000-pound total on which Model III is based. If this increased output is allocated among producing regions on the basis of no increase in supply price in any region as a result of increased output, most of the increased consumption would be supplied by Region 10. The Region 10 output would be roughly 374,000,000 pounds, an increase of 77,300,000 pounds over the amount allocated in Model III. The output in Region 8 (Washington) would increase over the Model III allocation by 1,400,000 pounds.

TABLE 29

SUMMARY OF MODELS WITH REGIONAL PRODUCTION ALLOCATIONS IN PERCENTAGES

Model No.	Conditions and/or assumptions	Type of container	Region 1	2	3	4	5	6	7	8	9	10	Mexico
			Allocation—per cent of total*										
I	Estimated 1955 regional production and consumption; transportation cost minimization at 1955 rates	Retail	0	1	1	5	0	1	1	14	35	38	3
		Institutional	0	7	0	7	1	1	1	12	25	39	6
II	Estimated 1955 regional consumption; production and transportation cost minimization at 1955 transportation rates and 1958 production costs	Retail	0	0	0	0	0	0	0	1	1	95	3
		Institutional	0	0	0	0	0	0	0	2	1	90	6
III	Estimated 1970 consumption at 1955 per capita consumption rates; production and transportation cost minimization based on estimated 1958 cost levels	Retail	0	0	0	0	0	0	0	1	1	95	3
		Institutional	0	0	0	2	0	0	0	2	2	89	5
IV	Same as Model III except for an assumed 50 per cent increase in all transportation rates	Retail	0	26	0	1	0	0	0	1	1	67	3
		Institutional	0	22	0	2	0	0	0	3	2	66	5
V	Same as Model III except an assumed ¾ cent per pound price premium for Region 8 and Region 9 strawberries	Retail	0	0	0	0	0	0	0	74	1	22	3
		Institutional	0	0	0	0	0	0	0	79	2	14	5
VI	Same as Model III except that Region 2 is assumed to develop a cost-reducing technique	Retail	0	72	0	0	0	0	0	1	1	23	3
		Institutional	0	71	0	0	0	0	0	2	2	20	5
VII	Same as Model III except that Region 10 labor costs increase 10 per cent while other regional labor costs are constant	Retail	0	26	0	1	0	0	0	52	1	17	3
		Institutional	0	13	0	2	0	0	0	72	2	6	5
VIII	Same as Model III except that per capita consumption is increased 25 per cent	Retail	0	0	0	0	0	0	0	1	1	96	2
		Institutional	0	0	0	2	0	0	0	2	2	90	4
IX	Regional consumption same as Model VIII; regional production is restricted to a 75 per cent expansion of 1953–1957 average	Retail	0	0	0	0	0	0	0	12	9	77	2
		Institutional	0	10	0	2	0	0	0	15	49	21	4

* Does not necessarily total 100 due to rounding errors.

and gains of 1,300,000 and 700,000 pounds would occur in Region 9 (Oregon) and Region 4 (Tennessee).

When the increased 1970 consumption of Model VIII is considered along with a selected restriction on regional production expansion (Model IX), the proportion of total production allocated to California decreases from the roughly 93 per cent of Model III to about 44 per cent. Most of the drop in California production would occur in the large-size container category. The principal producing areas benefiting from such a shift would be Regions 8 and 9 (Washington and Oregon), with substantial gains also occurring in Michigan, and minor gains in Tennessee.

The results with the alternative models are summarized more briefly in table 29, which gives, for each model, the estimated percentage of the United States consumption of frozen strawberries produced in each region. Except for Model I, the distributions reflect solutions which minimize estimated long-run cost of production and distribution of total consumption. For Models III to IX, the percentage distributions relate to projected 1970 regional consumption.

The percentage distributions with Models I, II, III, and VIII reflect the heavy concentration of production previously noted in the Pacific Coast states—excepting Model I, which is based on the actual regional production pattern of 1955—with a heavy long-run concentration of this West Coast output in California. Similarly, the percentage distribution with Model IV shows the effect of substantial increases in transportation rates on the competitive advantage of producers most distant from major markets. The effect of an assumed price advantage of ¾ cent per pound for the fruit of Region 8 (Model V) is demonstrated in the table by comparison with the preceding models: the effect of a new cost-reducing technique assumed for Region 2 (Model VI) or an increase in labor costs in California (costs in other regions constant) as in Model VII is similarly apparent. In line with previous indications, the percentage distribution with Model VIII is essentially the same as with Model III except for a projected increase in 1970 per capita consumption rates. Finally, table 29 shows in percentage terms the wider long-run distribution of output among the various regions that results from restraint on the amount of regional increase in production at the fixed regional supply prices used in the preceding models.

In evaluating the results summarized in table 29 it is important to keep in mind the nature of the long-run solutions. These indicate—given the projected levels of regional costs and consumption—the expected long-run industry adjustments under the usual assumptions of perfectly competitive markets. Any deviations from these assumptions or from the projected values of the various parameters would, of course, modify the long-run results. It is also true that substantial deviations from the projected pattern may occur in the short run. Where substantial fixed investments are already made—for example in processing plants—short-run survival in regions not appearing as producers in the long-run solution might be expected for a considerable period, so long as net returns in the region were sufficient to cover variable costs.

The above circumstances emphasize the need for qualified acceptance of the results of specific long-run solutions, and they are the stimulus for the

numerous alternative models considered. The varying results with the alternative models do, in fact, emphasize that California's dominant advantage under the estimated structure of costs for 1958 is rather precarious and that small changes in certain aspects of costs or product pricing could eliminate a large part of it. This possibility directs attention again to the assumption of constant regional production costs over wide ranges in regional output that was applied throughout the analysis. It means that small departures from this assumption in the direction of increased supply price as output expands in the major producing regions—such as the Pacific Coast states and Michigan—would substantially reduce the heavy allocations of production to these regions that are suggested by several of the analytical models. Moreover, the differences in total average costs of production and processing among Regions 8, 9, and 10 are so small that these costs might well be considered equal. It seems especially reasonable, in view of their similarities as to location, production conditions, and costs, to consider the total average costs in Regions 8 and 9 to be equal. If this were the case, production individually allocated to each of these regions should be jointly allocated to both regions.

The results of least-cost solutions based on the various models lead to two general conclusions concerning the frozen strawberry industry in the United States. First, the adjustment achieved by the industry in a past year (1955) differed substantially from the optimum indicated in this analysis when viewed in terms of volume of output. But when considered on the basis of possible cost reduction through better allocation of the consumption of that year among producing regions, the departure from the optimum was small. For practical purposes, the industry adjustment in that year may be regarded as good. Second, estimated current production, processing, and distribution costs show California to have had, in 1958, a cost advantage in most of the major consuming regions in the United States. Using the current structure of costs, a solution based on projected regional consumption in 1970 indicates that most of the total quantity of strawberries consumed in that year would be produced in California if aggregate costs were to be minimized. The cost differences, as compared with closely competing regions, however, are very small. Consequently, minor departures from values specified for certain cost determinants produce substantial changes in the quantities of output allocated to the various producing regions in the alternative models considered. Modification of the fixed-quantity assumption for Mexican imports would similarly change the solutions.

The changes introduced in the various models are disjunctive and therefore do not indicate the effects of the simultaneous change in several variables that might be expected to accompany change in the economic forces in this industry. They do, however, show conclusively that the locational advantage of California producers—when viewed in terms of the optimum allocation of projected 1970 volume—is not strongly established on a cost basis. Hence, large-volume shifts to closely competing regions might be expected if future conditions should result in cost or price movements adverse to California producers. The principal beneficiaries of the types of adjustment considered specifically in this study would be the Pacific Northwest and the producing regions centering on Michigan and Tennessee.

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APPENDIX TABLES

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Appendix Table A

ESTIMATED COSTS OF TRANSPORTING FROZEN STRAWBERRIES PACKED IN 10-OUNCE CARTONS, NET WEIGHT BASIS, 1955*

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	136	203	168	247	203	229	229	252	252	252	282
New Hampshire	125	191	160	220	203	229	229	252	252	252	282
Vermont	121	188	164	217	203	229	229	252	252	252	282
Massachusetts	128	194	155	218	203	229	229	252	252	252	282
Rhode Island	127	194	149	173	203	229	229	252	252	252	282
Connecticut	122	183	136	199	203	229	229	252	252	252	282
New York	101	171	145	200	203	229	229	252	252	252	282
New Jersey	113	167	117	181	203	216	229	252	252	252	258
Pennsylvania	103	177	109	167	213	208	229	252	252	252	258
Ohio	94	96	148	133	171	218	209	247	247	247	258
Indiana	132	95	163	104	140	201	177	247	247	247	258
Illinois	137	79	183	127	146	223	190	229	229	229	258
Michigan	122	58	168	138	170	247	210	247	247	247	258
Wisconsin	149	97	194	139	156	247	200	229	229	229	258
Minnesota	194	147	252	179	149	247	225	221	221	229	258
Iowa	182	135	225	155	113	247	191	221	221	221	258
Missouri	180	139	210	124	86	218	162	221	221	221	236
North Dakota	252	191	252	224	181	252	229	211	211	211	258
South Dakota	203	163	252	192	138	252	220	211	211	211	258
Nebraska	200	153	252	171	113	252	196	211	211	211	236
Kansas	225	183	252	165	85	252	168	211	211	211	236
Delaware	123	167	81	177	203	212	229	252	252	252	258
Maryland	116	154	95	164	215	198	226	252	252	252	258
District of Columbia	120	155	87	159	215	193	221	252	252	252	258
Virginia	132	166	61	151	221	179	213	252	252	252	258
West Virginia	124	133	122	122	179	187	198	252	252	252	258
North Carolina	150	179	69	141	211	158	196	252	252	252	258
South Carolina	174	183	118	128	199	132	171	252	252	252	258
Georgia	198	185	145	112	180	118	145	252	252	252	258
Florida	243	247	180	163	223	0	164	252	252	252	258
Kentucky	139	115	158	82	143	187	168	247	247	247	258
Tennessee	163	141	161	0	139	163	143	247	247	247	236
Alabama	190	169	168	88	150	140	119	247	247	247	236
Mississippi	216	187	201	120	140	159	78	247	247	247	236
Arkansas	208	174	208	113	100	192	114	221	221	221	236
Louisiana	252	210	221	143	152	164	0	229	229	221	211
Oklahoma	252	199	252	161	92	252	147	229	229	211	236
Texas	252	247	252	170	128	217	126	229	229	211	211
Montana	252	247	252	247	229	252	229	175	193	211	258
Idaho	252	247	252	247	229	252	229	140	128	166	258
Wyoming	252	227	252	247	229	252	229	211	211	211	258
Colorado	252	225	252	225	162	252	226	211	211	211	236
New Mexico	252	247	252	247	169	252	229	229	229	211	211
Arizona	252	247	252	247	229	252	205	183	183	161	211
Utah	252	247	252	247	229	252	205	189	177	178	236
Nevada	252	247	252	247	229	252	229	169	138	107	236
Washington	252	247	252	247	229	252	229	0	92	191	258
Oregon	252	247	252	247	229	252	229	92	0	162	258
California	252	247	252	247	229	252	205	208	177	87	211

* Estimated from gross transportation rates (table 18) by adjusting to net weight basis. Adjustment factor is 1.16667.

Appendix Table B

ESTIMATED COSTS OF TRANSPORTING FROZEN STRAWBERRIES PACKED IN 30-POUND TINS, NET WEIGHT BASIS, 1955*

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	124	185	154	226	186	209	209	230	230	230	258
New Hampshire	114	175	146	201	186	209	209	230	230	230	258
Vermont	111	172	150	198	186	209	209	230	230	230	258
Massachusetts	117	178	141	199	186	209	209	230	230	230	258
Rhode Island	116	177	136	158	181	209	209	230	230	230	258
Connecticut	112	168	124	182	186	209	209	230	230	230	258
New York	92	157	132	183	186	209	209	230	230	230	258
New Jersey	103	153	107	166	186	197	209	230	230	230	236
Pennsylvania	94	162	99	152	194	190	209	230	230	230	236
Ohio	86	88	135	122	157	199	191	226	226	226	236
Indiana	120	87	149	95	128	184	162	226	226	226	236
Illinois	126	72	167	116	134	204	174	209	209	209	236
Michigan	111	53	153	126	156	226	192	226	226	226	236
Wisconsin	136	89	177	212	143	226	183	209	209	209	236
Minnesota	177	135	230	164	136	226	206	202	202	209	236
Iowa	166	123	205	142	104	226	175	202	202	202	236
Missouri	165	127	192	113	79	200	148	202	202	202	215
North Dakota	230	175	230	204	165	230	209	193	193	193	236
South Dakota	186	149	230	176	127	230	201	193	193	193	236
Nebraska	183	140	230	156	104	230	179	193	193	193	215
Kansas	206	168	230	151	184	230	153	193	193	193	215
Delaware	112	153	74	162	186	194	209	230	230	230	236
Maryland	106	141	87	150	197	181	206	230	230	230	236
District of Columbia	110	142	80	145	196	177	202	230	230	230	236
Virginia	121	152	56	138	202	164	194	230	230	230	236
West Virginia	114	122	112	112	164	161	181	230	230	230	236
North Carolina	138	164	63	129	193	145	180	230	230	230	236
South Carolina	159	167	108	117	182	121	156	230	230	230	236
Georgia	181	169	132	102	165	108	132	230	230	230	236
Florida	222	226	165	149	204	0	150	230	230	230	236
Kentucky	127	105	145	75	131	171	154	226	226	226	236
Tennessee	149	129	147	0	127	149	131	226	226	226	215
Alabama	173	155	154	80	137	128	109	226	226	226	215
Mississippi	198	171	184	110	128	145	71	226	226	226	215
Arkansas	191	159	190	104	91	176	104	202	202	202	215
Louisiana	230	192	202	131	139	150	0	209	209	202	185
Oklahoma	230	182	230	147	85	230	135	209	209	193	186
Texas	230	226	230	156	117	199	115	209	209	193	152
Montana	230	226	230	226	209	230	209	160	177	193	236
Idaho	230	226	230	226	209	230	209	128	117	151	236
Wyoming	230	207	230	226	209	230	209	193	193	193	236
Colorado	230	205	230	205	148	230	207	193	193	193	215
New Mexico	230	226	230	226	154	230	209	209	209	193	190
Arizona	230	226	230	226	209	230	188	167	167	147	190
Utah	230	226	230	226	209	230	188	173	162	163	215
Nevada	230	226	230	226	209	230	209	155	126	98	215
Washington	230	226	230	226	209	230	209	0	84	175	236
Oregon	230	226	230	226	209	230	209	84	0	148	236
California	230	226	230	226	209	230	188	191	162	79	190

* Estimated from gr[illegible]ansportation rates (table 18) by adjusting to net weight basis. Adjustment factor is 1.06667.

Appendix Table C

ESTIMATED COSTS OF TRANSPORTING FROZEN STRAWBERRIES PACKED IN 10-OUNCE CARTONS, NET WEIGHT BASIS, 1957*

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	150.841	224.526	186.448	252.420	257.641	256 833	260.353	284.384	286.510	287.740	279.133
New Hampshire	138.197	211.882	176.856	244.146	256.176	255.721	259.241	282.838	285.045	286.274	277.668
Vermont	134.192	207.958	182.088	240.222	255.721	256.327	259.224	282.384	284.590	285.820	277.213
Massachusetts	141.539	215.224	171.188	241.239	256.563	255.064	258.584	283.226	285.432	286.662	277.566
Rhode Island	140.958	214.643	165.084	236.007	255.873	254.357	257.877	283.158	285.365	286.544	276.859
Connecticut	135.581	203.016	150.260	220.311	254.155	252.639	256.159	281.811	283.731	284.826	275.141
New York	111.383	189.791	160.142	222.055	253.616	253.784	256.681	280.278	282.485	283.714	275.107
New Jersey	125.008	185.140	130.107	200.836	252.083	238.914	253.902	279.739	281.659	282.754	272.884
Pennsylvania	114.153	167.118	120.260	184.559	235.571	230.484	252.016	277.651	279.520	280.666	270.998
Ohio	104.151	106.265	163.485	147.789	189.936	241.094	231.647	271.318	273.524	274.754	266.130
Indiana	145.754	105.424	181.071	114.933	154.765	222.636	196.621	269.633	270.610	271.301	262.054
Illinois	152.294	87.763	202.290	141.103	162.322	246.762	210.283	266.534	268.842	270.071	263.368
Michigan	134.854	64.794	186.012	152.440	188.773	251.931	232.229	270.004	272.177	273.406	266.181
Wisconsin	165.084	107.721	215.079	153.893	173.077	252.774	221.619	165.271	267.579	270.408	264.614
Minnesota	214.643	163.049	253.363	198.656	164.648	257.995	249.523	259.309	261.616	266.804	263.452
Iowa	201.127	149.242	248.942	172.060	125.725	254.879	212.027	262.492	263.081	264.311	259.107
Missouri	199.673	154.038	232.955	137.179	95.715	241.966	179.036	266.720	265.827	265.103	256.799
North Dakota	253.211	211.736	259.005	247.779	200.109	263.654	256.311	254.306	256.614	262.391	266.046
South Dakota	225.252	181.071	255.452	212 899	153.312	259.494	243.274	257.843	260.151	263.065	261.195
Nebraska	221.474	169.589	253.616	189.064	125.544	256.445	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	128.201	170.316	105.213	181.797	238.187	219.875	250.250	278.021	279.941	281.171	270.678
District of Columbia	133.184	171.624	96.862	176.275	238.042	214.352	244.727	278.173	280.093	280.952	269.734
Virginia	146.481	184.413	67.426	167.118	244.582	198.365	235.571	279.520	281.255	281.221	268.977
West Virginia	137.906	147.789	135.435	135.581	198.365	207.376	219.727	274.568	275.899	276.404	265.086
North Carolina	166.682	198.801	76.242	156.364	233.827	175.548	217.550	280.480	281.811	279.975	266.888
South Carolina	192.843	202.289	130.288	142.266	220.456	146.190	189.645	280.110	280.783	277.415	263.654
Georgia	218.858	204.906	160.288	123.566	199.964	130.288	160.288	279.571	278.948	274.653	260.252
Florida	253.397	252.807	199.819	180.344	246.907	†	181.652	285.836	284.944	278.948	262.761
Kentucky	154.184	127.144	175.548	90.487	158.253	207.522	186.157	271.537	272.059	271.756	261.145
Tennessee	181.071	155.928	178.455		153.602	180.344	158.544	273.693	273.069	270.509	258.315
Alabama	210.138	187.611	186.303	97.093	165.956	155.637	132.628	276.455	275.562	270.762	257.085
Mississippi	239.641	207.086	223.072	133.016	154.620	175.839	86.246	274.989	273.524	267.225	252.824
Arkansas	230.920	193.133	230.775	125.544	110.376	213.044	126.258	271.099	270.139	264.547	252.251
Louisiana	253.397	232.229	244.582	158.544	168.281	181.652		275.107	273.642	267.343	239.350
Oklahoma	252.942	220.020	255.334	177.873	102.431	253.060	163.194	265.608	264.143	258.551	240.222
Texas	256.614	251.931	256.361	188.773	142.121	240.949	139.069	268.909	267.444	260.825	196.040
Montana	262.610	256.631	268.404	260.774	254.104	273.053	263.873	194.005	213.916	253.700	269.600
Idaho	269.937	263.924	275.141	265.271	257.877	277.145	265.844	154.620	141.975	183.396	267.650
Wyoming	258.382	251.267	264.176	254.542	212.754	266.416	256.647	243.274	244.001	252.706	262.374
Colorado	257.506	248.797	261.684	248.942	179.181	163.284	250.686	255.148	253.683	254.323	257.372
New Mexico	261.667	256.311	264.665	252.639	187.175	261.077	231.066	257.338	255.873	228.886	245.018
Arizona	269.128	263.772	272.126	260.100	251.558	267.915	256.024	257.911	253.852	178.600	253.582
Utah	264.715	258.702	269.920	260.050	251.915	271.116	259.511	209.266	196.621	197.639	261.313
Nevada	273.625	267.612	278.830	268.960	260.690	278.493	266.888	187.756	152.730	118.949	266.787
Washington	275.528	269.549	281.322	273.693	266.804	285.836	275.107		102.213	214.643	276.910
Oregon	277.735	271.722	282.939	273.069	265.675	284.944	273.642	102.213		179.617	275.444
California	275.950	270.593	278.948	266.922	258.669	275.360	263.755	230.920	195.895	95.943	262.037

* Cost estimates for distances of 1,220 miles or less are 10.8 per cent higher than 1955 truck transportation estimates at these distances. Estimates for distances in excess of 1,220 miles are found from the following equation:

transportation cost = 231.34921 + 0.016843 (distance in miles as given in table 17).

This equation is based on published rate-distance data for 1957 and has been adjusted to a net weight basis. For this reason, and because Appendix Table A is based on 1955 step-cost relationships for rail transport, tables A and C are not comparable.

† Blanks signify zero transportation costs, indicating that the same point has been chosen as both the production and consumption point.

APPENDIX TABLE D

ESTIMATED COSTS OF TRANSPORTING FROZEN STRAWBERRIES PACKED IN 30-POUND TINS, NET WEIGHT BASIS, 1957*

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	137.912	205.281	170.467	230.785	235.559	234.820	238.038	259.937	261.954	263.079	255.209
New Hampshire	126.351	193.721	161.697	223.220	234.219	233.803	237.022	258.597	260.615	261.739	253.869
Vermont	122.690	190.133	166.481	219.632	233.803	234.358	237.006	258.181	260.199	261.323	253.454
Massachusetts	129.408	196.777	156.514	220.562	234.573	233.203	236.421	258.951	260.969	262.093	253.777
Rhode Island	128.876	196.245	150.934	215.778	233.942	232.556	235.774	258.890	260.907	261.985	253.130
Connecticut	123.960	185.615	137.380	201.428	232.371	230.985	234.204	257.658	259.413	260.414	251.559
New York	101.836	173.523	146.416	203.022	231.878	232.032	234.681	256.256	258.274	259.398	251.529
New Jersey	114.293	169.271	118.955	183.622	230.477	218.436	232.140	255.764	257.519	258.520	249.496
Pennsylvania	104.369	152.794	109.952	168.740	215.380	210.729	230.415	253.854	255.563	256.611	247.771
Ohio	95.223	97.157	149.472	135.121	173.656	220.429	211.792	248.064	250.081	251.205	243.320
Indiana	133.261	96.387	165.550	105.081	141.500	203.554	179.768	246.524	247.417	248.048	239.594
Illinois	139.241	80.241	184.951	129.009	148.409	225.611	192.259	243.690	245.800	246.924	240.795
Michigan	123.305	59.240	170.068	139.374	172.593	230.338	212.324	246.862	248.849	249.973	243.367
Wisconsin	150.934	98.488	196.644	140.702	158.242	231.108	202.623	242.535	244.645	247.232	241.934
Minnesota	196.245	149.074	231.647	181.629	150.535	235.882	228.136	237.083	239.193	243.936	240.872
Iowa	183.888	136.450	227.605	157.312	114.949	233.033	193.853	239.994	240.533	241.657	236.899
Missouri	182.559	140.835	212.988	125.421	87.511	221.226	163.690	243.859	243.043	242.381	234.789
North Dakota	231.509	193.588	236.806	226.541	182.958	241.057	234.342	232.510	234.619	239.902	243.243
South Dakota	205.945	165.550	233.557	194.651	140.171	237.253	222.422	235.744	237.853	240.518	238.808
Nebraska	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Maryland	117.212	155.718	96.195	166.215	217.772	201.029	228.800	254.193	255.948	257.073	247.478
District of Columbia	121.768	156.913	88.560	161.166	217.639	195.980	223.751	254.331	256.087	256.872	246.616
Virginia	133.926	168.607	61.646	152.794	223.618	181.363	215.380	255.563	257.150	257.119	245.923
West Virginia	126.086	135.121	123.827	123.960	181.363	189.601	200.896	251.036	252.252	252.714	242.366
North Carolina	152.396	181.762	69.707	142.961	213.785	160.501	198.903	256.441	257.658	255.979	244.013
South Carolina	176.314	184.951	119.121	130.072	201.560	133.660	173.390	256.102	256.718	253.638	241.055
Georgia	200.099	187.342	146.549	112.975	182.825	119.121	146.549	255.610	255.040	251.113	237.946
Florida	231.678	231.139	182.692	164.886	225.744	†	166.082	261.338	260.522	255.040	240.240
Kentucky	140.968	116.246	160.501	82.731	144.689	189.734	170.201	248.264	248.741	248.464	238.762
Tennessee	165.550	142.563	163.159		140.437	164.886	144.954	250.235	249.665	247.324	236.175
Alabama	192.126	171.530	170.334	88.770	151.731	142.297	121.260	252.761	251.944	247.555	235.051
Mississippi	219.100	189.336	203.952	121.615	141.367	160.767	78.853	251.421	250.081	244.321	231.154
Arkansas	211.128	176.579	210.995	114.783	100.915	194.784	115.436	247.863	246.986	241.873	230.631
Louisiana	231.678	212.324	223.618	144.954	153.857	166.082		251.529	250.189	244.429	218.835
Oklahoma	231.262	201.162	233.449	162.628	93.651	231.370	149.206	242.843	241.503	236.390	219.632
Texas	234.619	230.338	234.388	172.593	129.939	220.296	127.149	245.861	244.522	238.469	179.237
Montana	240.102	234.635	245.399	238.423	232.325	249.650	241.257	177.377	195.581	231.955	246.493
Idaho	246.801	241.303	251.559	242.535	235.774	253.392	243.059	141.367	129.806	167.677	244.706
Wyoming	236.236	229.731	241.534	232.725	194.519	243.582	234.650	222.422	223.087	231.047	239.886
Colorado	235.436	227.472	239.255	227.605	163.823	240.718	229.199	233.280	231.940	232.525	235.312
New Mexico	239.239	234.342	241.981	230.985	171.131	238.700	211.261	235.282	233.942	209.267	224.017
Arizona	246.062	241.164	248.803	237.807	229.996	244.953	234.080	235.805	232.094	163.292	231.847
Utah	242.027	236.529	246.785	237.761	230.323	247.879	237.268	191.329	179.768	180.699	238.916
Nevada	250.173	244.676	254.932	245.908	238.346	254.624	244.013	171.663	139.639	108.753	243.921
Washington	251.914	246.447	257.211	250.235	243.936	261.338	251.529		93.452	196.245	253.176
Oregon	253.931	248.433	258.690	249.665	242.905	260.522	250.189	93.452		164.222	251.837
California	252.299	247.401	255.040	244.044	236.498	251.760	241.149	211.128	179.104	87.720	239.576

* Cost estimates for distances of 1,220 miles or less are 10.8 per cent higher than 1955 truck transportation estimates at these distances. Estimates for distances in excess of 1,220 miles are found from the following equation:

transportation cost = 211.51934 + 0.015400 (distance in miles as given in table 17).

This equation is based on published rate-distance data for 1957 and has been adjusted to a net weight basis. For this reason, and because Appendix Table B is based on 1955 step-cost relationships for rail transport, tables B and D are not comparable.

† Blanks signify zero transportation costs indicating that the same point has been chosen as both the production and consumption point.